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THE ROYAL ENGINEERS JOURNAL.

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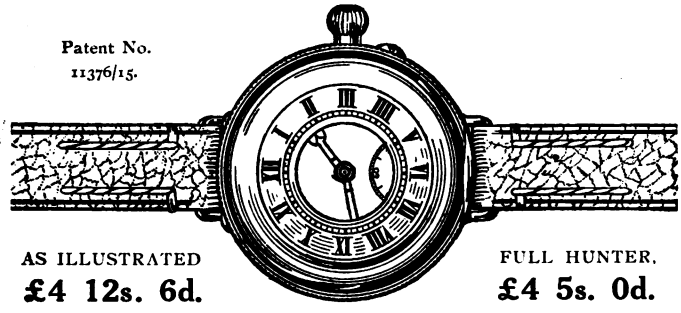

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MILITARY EXPLOSIVES OF TO-DAY.

Cantor Lectures by J. Young, Esq., O.B.E., delivered before the Royal Society of Arts on April 8, 15, and 22, 1918. These Lectures are published by permission of the Royal Society of Arts in anticipation of their appearance in the Society's Journal.
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LECTURE I.

THE subject of explosives is one of the most fascinating branches of chemistry, although studied by comparatively few. Everyone has a general idea of what an explosive is, and yet there is no subject on which the laity are more intensely ignorant, and most seem ready to believe any of the fairy tales of wonderful new explosives which appear at regular intervals.

For instance; early in the War we heard of a French explosive called Terpenite, which killed Germans by the hundred and left them frozen stiff without a mark on them. More recently we heard of an American explosive of which a thimbleful would lift St. Paul's from its foundations. The chemist who understood explosives did not need to even investigate the stories; he knew that they were mere fiction.

The fact is there have been no epoch-making discoveries in explosives such as, say, the discovery of nitroglycerine, for many years. None are likely to be made until someone discovers how to dissociate elements into their primitive constituents in a fraction of a second, in the same way as radium does in a million years or so; and there is little prospect of this at present.

Nitroglycerine, discovered in 1846, still remains the most powerful explosive in practical use. Many useful advances have been, and are being made, but new explosives are merely new mixtures of old materials, given fancy names. The nations at war use practically the same explosives, and no one can be said to be ahead of the others.

I propose first to deal briefly with the principles governing the subject, since it is by the application of these that any claims for a new explosive must be decided. They were first laid down by the great French chemist Berthelot in his work *Explosives and their Power* (*la Puissance des Substances Explosifs*), a work which can still be consulted with advantage by those interested.

Definition.—An explosive is a substance in which a chemical action, once started, proceeds with considerable velocity, and with evolution of heat and gas. It must be self-supporting, and independent of outside agencies.

When the substance is enclosed the pressure of the gases bursts the envelope, and the shock gives rise to an air wave. We say the substance has "exploded."

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Total energy evolved is given out as heat, and may be measured in the bomb calorimeter. But in order to utilize the heat for doing useful work a gas is required. This, by its expansion, propels the shell or bullet, or disrupts the surrounding material. *The Power of doing Useful Work* is proportional to the volume of gas per unit weight of the explosive, and its temperature. The temperature is not known with any degree of accuracy, but if we assume that the specific heats of the gases evolved by different explosives are the same it will be proportional to the quantity of heat evolved.

Coefficient of Potential Energy.—The quantity of heat, and volume of gas evolved, can be measured with considerable accuracy in the bomb calorimeter, and the product—

Vol. of gas per gram (reduced to N.T.P.) × *Calories per gram* is called the coefficient of potential energy, and affords a useful and reliable means of comparing the powers of different explosives, especially those slow in action, such as smokeless powders. Substances like water, which are gaseous at the temperature of the explosion, are reckoned as gases.

The following table gives such a comparison of some of the most typical explosives in use :—

Name of Explosive.	Vol. of Gas per gram in C.Cs.=V.	Calories per gram =Q.	Coefficient =Q×V ÷1000.	Coeff. G.P.=1.	Calculated Temperature $=\frac{Q}{C}$. Assuming C=.24 C=sp. ht. of gases.
Gunpowder	280 c.c.	738	207	1	2240° C.
Nitroglycerine	741 ,,	1652	1224	6	6880 ,,
Nitrocellulose (13 per cent. Nitrogen)	923 ,,	931	859	4·3	3876 ,,
Cordite, Mk. I. (N.G.=57. N.C.=38. Vaseline=5) ...	871 ,,	1242	1082	5·2	5175 ,,
Cordite, M.D. (N.G.=30. N.C.=65. Vaseline=5) ...	888 ,,	1031	915	4·4	4225 ,,
Ballistite (N.G.=50. N.C.=50. Stabilizer=·5) ...	817 ,,	1349	1102	5·3	5621 ,,
Picric Acid (Lyddite) ...	877 ,,	810	710	3·4	3375 ,,

The coefficients correspond fairly well with the results obtained in practical use. The temperatures are certainly too high, as no allowance has been made for the increase in the sp. ht. of gases at high temperatures, but they are in the correct order. The actual sp. ht. of gases at such temperatures is not known, and any correction introduced would still leave the matter uncertain.

An experiment quoted by McNab, in which diamonds were found on carbon rods exposed to the flame of exploding cordite, shows that the temperature was certainly above 4,000° C.

The table shows that nitroglycerine is most powerful, and that in mixtures of it with nitrocellulose the power is proportional to the amount of N.C., which is in accord with practice. Also that the

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power depends more on the amount of heat evolved than on the volume of gas. Explosives like nitrocellulose, which evolve a large volume of gas, are deficient in oxygen, and the gas is mostly CO. In those like nitroglycerine, where part of the carbon is replaced by oxygen, the gas is CO_2, and the diminution in volume is more than compensated by the extra heat evolved.

Solid products of combustion are unable to expand and do work, although they absorb their proportion of the heat. They are inactive, and merely produce smoke and fouling; 57 per cent. of the products of combustion of gunpowder are solids, which explains its weakness and defects.

The temperature of explosion is of great importance in the case of smokeless powders, as it is found that the erosion and consequent wear of a gun increases rapidly with an increase of temperature.

As examples of different kinds of explosives I first heat some ammonium bichromate in a test tube. At a certain temperature it ignites, and the internal combustion which takes place continues without further application of heat. Large volumes of nitrogen gas and steam are given off, and a residue of chromium oxide many times bulkier than the original substance is left.

$$(NH_4)_2Cr_2O_7 = N_2 + 4H_2O + Cr_2O_3 + \text{Heat}.$$

It is a true explosive, but a very bad one. It gives little gas (440 c.c. per gram), little heat, and a huge residue.

A little gunpowder, when ignited, flashes off, and besides gas gives a cloud of smoke due to solid residue.

A piece of cordite burns slowly, gives only a trace of smoke, and leaves no residue.

Some loose guncotton flashes off rapidly, because of its porosity, but leaves no residue or smoke.

Products of Combustion.—The products of combustion depend on the pressure under which the explosive burns, except in the case of gunpowder. Smokeless powders, and most modern high explosives, when burnt under atmospheric pressure give off oxides of nitrogen which are highly poisonous. But under fairly high pressure, as in a gun, the nitrogen comes off as free gas and is harmless.

A simple experiment will show exactly what takes place in a gun when it is fired (*Fig.* 1).

A tall glass cylinder is filled with water, and a wide glass tube a little

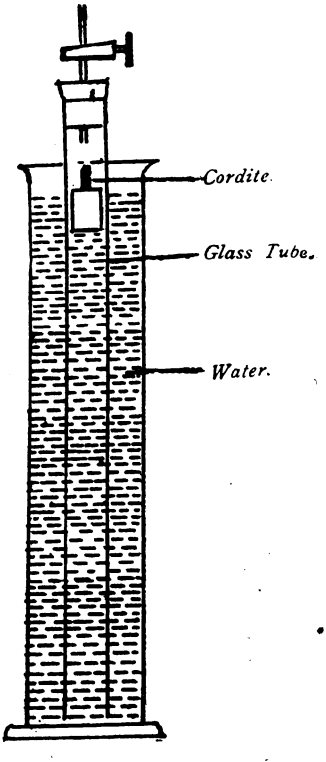

FIG. 1.

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longer than the cylinder is immersed in it. The tube is fitted with a cork and stopcock, and another cork smaller in diameter than the tube, so that it can slide easily inside it, is fitted with a piece of glass tube to act as holder for a piece of cordite (about .5 c.c.). I drop the cork with its piece of cordite into the tube so that it floats on the water, then ignite the cordite, and quickly insert the upper cork with stopcock closed. The cordite is seen to burn steadily, giving off gas which drives the cork and water to the bottom of the tube, any excess of gas then escaping.

The tube represents the gun, the cork and water the shell. As the cordite burns the shell moves forward, enlarging the spaces and preventing any dangerous pressures. In the ideal gun the charge has just finished burning as the shell reaches the muzzle.

In the actual gun the rate of combustion of the cordite increases as the pressure rises, but the charge is ignited over the whole of its surface simultaneously, and the total time of combustion is that necessary to burn through half the diameter, or thickness, of a single cord or strip.

The gases contain 40 per cent. of CO and 13 per cent. of hydrogen, and are inflammable. On opening the tap and applying a light they are seen to burn. It is these which give the bright muzzle flash of a gun, and also, sometimes, the back flash when the breech is opened, which is a source of danger to the gunners.

On raising the tube and allowing air to enter the gases turn brown, showing that under these conditions they contain nitric oxide, NO.

True explosion is of this kind, and is merely rapid combustion. The substance is ignited at the surface and burns until the whole is consumed, the time of combustion of a charge varying with the size of the grains, sticks, etc. Detonation is a phenomenon of an entirely different order.

Detonation is the almost instantaneous disruption of a compound or mixture into its elements or simpler compounds, with evolution of heat and gas. Whereas the rate of explosion is measured in centimetres per second the rate of detonation is from 3,000 to 10,000 metres per second.

If we consider a 13.5-in. shell filled with lyddite of density 1.6, and velocity of detonation 7,000 metres per second. The detonator is central, and the detonation has to travel through, roughly, one sixth of a metre. Hence, in $1/6 \times 1/7000 = 1/42000$th of a second the whole is converted into gas, occupying $1.6 \times 877 = 1,242$ times the original volume at 0° C., but at a temperature of 3,375° C. The time occupied in the development of the gas is so short that the shell—or even the atmosphere alone—acts as tamping, and the substance detonates in its own volume, the theoretical pressure developed being 11.500 atmospheres, or 77 tons per sq. in. For an instant the shell is intact and filled with gas at this pressure, the next instant it dissolves, and this giant force is applied as a blow to any body in

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contact with it. Guncotton will cut through its own thickness of iron, and it is probable that lyddite would destroy its own thickness of any material opposed to it, if detonated in intimate contact with it.

Such detonating substances are called *High Explosives*, and their immense shattering effect is due, not only to the volume of gas and quantity of heat, but also to the velocity of detonation and density of the explosive. Shattering power is proportional to—

Vol. of gas per gram × Cals. per gram × Vel. of detonation × Density.

The disruptive effect is exerted chiefly in the direction in which the wave of detonation is travelling. In a shell with a central axial detonator it is at right angles to the axis of the shell. This explains some of the apparently erratic effects of H.E. shells.

The effects of H.E. shells are very local, and to obtain full shattering effect it must be detonated in intimate contact with the body to be destroyed. To destroy armour plate or concrete walls the shell should have a delay-action fuze, so as to allow it time to penetrate. Shells with instantaneous fuzes have been known to fail to damage a tank, because the shell detonated before coming into close contact with it. On the other hand we have had examples of German aeroplane bombs with such fuzes, which make no crater, as their main effect is lateral. These are meant for man-killing.

The very intensity of the effect of high-velocity detonating explosives diminishes the radius of these man-killing power, as the metal is blown to dust. A lower-velocity explosive gives larger pieces and projects them further.

Detonating Compounds.—In the molecule of a detonating compound each atom is combined with others for which it has little affinity. Take, for example, nitroglycerine, $C_3H_5(NO_3)_3$. The carbon atoms are combined with hydrogen, for which they have little affinity, and the nitrogen with oxygen and carbon. There is a constant tendency to decompose, and such a compound may be quite stable, while undisturbed, but the moment that the cohesion between the atoms is destroyed in any way it falls into its constituent atoms, which immediately re-assemble and combine to form compounds of greatest stability, and give out energy in the process. We say it has *detonated*, and the detonation passes on from particle to particle through the mass.

$$2C_3H_5(NO_3)_3 = 6CO_2 + 5H_2O + 3N_2 + O + \text{Heat}.$$

To Start Detonation.—Detonation may be started in several ways.

(1). *By Heat.*—For every compound there is a temperature limit at which it decomposes, and if a detonating compound be heated to this temperature it will detonate fully. But in most cases the heating must be very rapid, as most high explosives undergo a lower order of decomposition at a lower temperature, and do not even explode. Nitroglycerine, rapidly heated, detonates with great violence, but

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heated a little more slowly decomposes with evolution of red fumes. Picric acid ignites and burns with a smoky flame, but if a little be projected on to a white hot plate it will flash off, or even detonate. Similarly with T.N.T. and others.

2. *By Shock.*—Any kind of percussive shock, such as a blow on an anvil, will detonate an H.E., if sufficiently intense ; but a comparatively small shock will suffice *if of the right kind.* It seems as if for each substance a particular kind of vibration was necessary, and this is the kind which it gives out itself when detonating. Examples :

The shock of exploding gunpowder will not detonate guncotton, picric acid, T.N.T., or nitroglycerine.

The shock of detonating N.G. will not detonate guncotton.

The shock of detonating guncotton will detonate N.G.

Gunpowder is incapable of detonation. Fulminate of mercury will detonate all the above with the exception of T.N.T. cast into slabs and untamped, but with the addition of a little lead azide will detonate them fully.

Increasing the quantity of the initiator of detonation above a certain minimum has little effect. One gram of fulminate will detonate an unlimited amount of picric acid. No amount of gunpowder would do it.

A fulminate detonator provides combined shock and sudden heating, and is, therefore, very effective.

The Explosive Wave.—When a substance detonates a wave which seems to contain a particular vibration peculiar to each substance is thrown out. This sweeps through the substance, detonating each molecule in turn. It is self-regenerating. This is Abel's theory, and is almost certainly true for pure chemical compounds. Berthelot's theory that it is merely a wave of pressure which heats the particles which resist it leaves many phenomena unexplained.

For instance : The more suitable the physical state of the substance for transmitting vibrations the greater the velocity of detonation, and the greater the certainty when once started. It is best when homogeneous and dense, up to a certain point. The velocity of detonation is approximately the same as that of sound in the substance, and sound we know to be a vibration. Gelatinized substances do not transmit vibrations well, and are difficult to detonate.

Liquid nitroglycerine is easy to detonate, and the wave travels well. Frozen N.C. is crystalline. The separate crystals are more sensitive than the liquid, but it behaves erratically, and a portion may be blown away undetonated.

Dry guncotton is porous, and the pores filled with air. It is comparatively easy to detonate. Wet guncotton is quite incombustible, and difficult to detonate, but once started it detonates with greater velocity than dry, as water transmits vibrations more rapidly than air.

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Detonation is more easily started in powder or crystals, probably because there is a less mass to take the initial shock, but the wave travels slowly, and may die out in a loose powder. Advantage is taken of this fact in detonating shells. Detonation is first set up in crystals or pellets and transmitted to the dense filling.

Mixtures of H.E. which require different waves are always difficult to detonate. The wave which suits one does not suit the other, and may die out before it has gone very far.

The most striking example is cordite. It contains 57 per cent. of N.G., and 38 per cent. of guncotton, both sensitive substances which detonate easily. It is completely gelatinized. It can be detonated by percussion, but only the portion under the hammer; the wave dies out immediately. Even a fulminate detonator will only detonate about 2 lbs., however large the charge, the amount being evidently proportional to the initial percussive blow. Two detonators will detonate, roughly, 4 lbs.

Amatol, a mixture of T.N.T. and ammonium nitrate, is more difficult to detonate than pure T.N.T.

Another Kind of Detonation.—In the case of many H.E. mixtures much used at present it is probable that the detonation is of a different order. The mixture contains at least one detonating constituent, the remainder being combustibles and supporters of combustion of the nature of gunpowder. Fulminate detonators are used. The detonator, besides delivering a shock, sends a wave of intensely heated gas at high velocity into the charge. The detonating constituent detonates, and this, along with the fulminate, sends a wave of hot gas through the mass which causes the almost instantaneous combustion of the other constituents. For this kind of detonation porosity is an advantage, and also several detonators in a large charge. The charge should also be tamped. Mixtures for mining are always made in this porous form; when they set into a solid block, as sometimes happens, they are insensitive, and should be sent back to be re-worked.

Such detonation is more of the nature of a rapid explosion than true detonation, and is much slower. The average rate of mixtures in use is 3,000 to 4,000 metres per second.

Sympathetic Detonation.—The detonating wave can be transmitted through air, earth, water or other materials, and detonate charges at a distance, which are said to detonate in sympathy. As might be expected the greater the facility which the intervening medium offers for the transmission of vibrations the greater the distance at which charges will detonate in sympathy. This applies only to the true detonating wave.

Examples.—If dry guncotton primers are placed ½-inch apart in air, and one detonated, all the others detonate. If they are separated

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by tin screens the result is the same. If placed in an iron tube, which would confine the wave, they may be 5 ft. apart.

Berthelot states that when 100 gram cartridges of dynamite, 75 per cent. N.G., are placed on firm ground 30 cms. apart the detonation of one will extend to all the others. If placed on an iron rail the distance may be increased to 70 cms.

Also, that 5 kilos. detonated under water detonated other charges 3 metres distant, and the distance is proportional to the charge.

From this it is evident that in a shell dump the detonation of one shell would probably detonate all in contact with it, although others a few yards distant would escape. A torpedo may detonate the shells in the magazine of a warship, and a submarine mine do the same. One submarine mine will detonate all others within a certain radius. Countermining depends on this principle.

Very Rapid Explosion may approach detonation in effects. To show this I ignite a small amount of gunpowder—about 1 c.c. It flashes off quietly. I put the same amount in a copper tube left open at the upper end, and heat it with a bunsen burner. By this means the whole reaches the temperature of ignition at the same moment, and when it explodes there is a report like that of a pistol.

A substance may either detonate, or merely explode (burn), according to the treatment. For example :—

Fulminate of mercury, when unenclosed and ignited, burns with a sudden flash. But when struck on an anvil detonates with a sharp report.

A spot of nitroglycerine on a piece of filter paper, when struck on the anvil, detonates violently. But a paper soaked in N.G. burns quietly with a greenish flame.

Picric acid, or T.N.T., as already stated, burn quietly when ignited, but can be detonated by percussion, or the shock of a detonator.

Cordite can be detonated by hammering, although the wave does not travel far. When ignited it burns regularly.

But this only applies to small quantities. When large masses are ignited they burn for a time, but the heat given out is almost certain to raise the temperature locally to the detonating point, and the remainder detonates. Cordite is a possible exception. The great explosions at Halifax and in N.E. London are examples.

The qualities which are desirable in an explosive intended for military use may be summed up as follows :—

A. *For Use as a Propellant in Guns and Rifles.*

(1). It should generate a large volume of gas at a moderately high temperature ; that is, be powerful but not too erosive.

(2). The rate of combustion should be uniform, and adjustable by varying the size of the stick or grain ; that is it must be absolutely non-porous or colloidal.

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(3). It must be uniform in quality, so that the shooting will not vary.

(4). It should have a high stability at ordinary atmospheric temperatures.

(5). It should not be liable to detonate by the shock of firing.

(6). It should produce no solid products of combustion, so as to be smokeless.

Cordite and N.C. powders comply fairly well with the requirements, and similar powders are universally used by civilized nations.

B. *A High Explosive for Filling Shells.*

(1). Should give a large volume of gas at as high a temperature as possible. Incendiary effect is desirable.

(2). Have a high density, so as to get as great a weight as possible in a given volume.

(3). Have a high velocity of detonation, when destruction of material is the object.

(4). Be incapable of detonation by the shock of firing or impact against a target.

(5). Should detonate completely and with certainty when the fuze acts.

Picric acid, T.N.T., and Amatol fulfil the requirements fairly well.

C. *An Explosive for Military Mines.*

(1). Should give much gas and heat, with a moderate velocity of detonation, so as to have a great lifting effect.

(2). Should be safe under ordinary shocks, even the impact of a rifle bullet.

(3). Should give no poisonous gases when detonated. Craters may have to be occupied, and mine galleries entered, shortly after the explosion.

(4). Should be detonated with certainty by a fulminate or similar detonator.

Ammonal, Blastine, and several other explosive mixtures comply well with the requirements.

D. *For Hasty Demolitions by the R.E.*

(1). It should be safe under the impact of a rifle bullet.

(2). Should have a high velocity of detonation.

(3). Should detonate completely with a fulminate detonator, and produce intense effects even when untamped. Slabs of wet gun-cotton comply best, and have been used for a long time. Slabs of picric acid and T.N.T. are also used. Commercial explosives of all kinds are also used when the conditions are suitable, *i.e.* in back areas.

Materials for Explosives.—Before commencing a description of the actual explosives themselves a few remarks on some of the essential materials required for their manufacture may be of advantage.

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Nitrates.—In the days when gunpowder was the only explosive saltpetre (potassium nitrate) was essential for the carrying on of a war. It was mostly imported from tropical countries, where it is most plentiful. During the Napoleonic wars the British command of the seas cut off the French from their overseas supplies, and threatened to stop the War in that way. But the French chemists studied the subject and developed methods for the artificial production of saltpetre which are worked to this day, although neglected of late years.

At present nitrates, or their equivalent nitric acid, are just as essential as saltpetre was in the old days, as all explosives used in guns or shells are products of nitric acid. If the present war had started 10 years earlier the Germans could not possibly have kept up their supply of nitrates. But the process for obtaining nitric acid from the atmosphere by the aid of electricity has now been well worked out. Huge works have been established in Germany, and there is little doubt that most of their supplies have been obtained from this source, and are practically unlimited. The process is being worked now in England.

Chlorates.—Potassium chlorate and ammonium perchlorate are much used. But the materials for the preparation of chlorates—electricity and common salt—are plentiful. Potash salts are almost a monopoly of Germany, but the small amounts necessary are easily obtained. There should be no danger of our running short of chlorates.

Cellulose, $C_6H_{10}O_5$.—This is essential for the manufacture of smokeless powders. Its purest natural form is cotton, and this is always used when available. Some chemists who should have known better thought that when the supplies of cotton were cut off the Germans would no longer be able to make nitrocellulose. But it had been shown long before the War that wood could be made to yield about 40 per cent. of good cellulose, and that from this a stable nitrocellulose could be made, although not quite so good as that from cotton. There is little doubt that at present most of the German nitrocellulose is made from wood pulp.

Glycerine, $C_3H_5(OH)_3$.—This is essential for the manufacture of nitroglycerine, which is a constituent of all powders used for heavy guns. The only source is animal and vegetable fats and oils, and the bitter cry from Germany in the early days of the War about the shortage of food fats meant that they were using their limited supplies for the manufacture of glycerine. Every cordite cartridge requires its own weight of fat for the glycerine alone. This statement will explain many things with regard to butter, margarine, cocoanut oil, copra, and similar tropical imported products.

Acetone, $(CH_3)_2CO$.—This is a fragrant liquid boiling at 60° C., which has the property of dissolving both guncotton and nitro-

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glycerine, and is essential in the manufacture of cordite M.D. It is made by distilling calcium acetate, which is a product of the distillation of wood.

Aluminium, in the form of powder, is much used in explosive mixtures. It is permanent at ordinary atmospheric temperatures, but when oxidized gives out a large amount of heat. Its manufacture depends on having a suitable ore and plenty of electric power. Works have long been established in both Britain and Germany, and many places on the Continent.

Some electric furnace products, such as calcium silicide, are also used, and various common metals and compounds.

The basic materials for the manufacture of high explosives for use in shells are all products of the distillation of coal, and come from the gasworks. They will be dealt with later. For these we are rather better off than other nations.

Explosive Mixtures.

Explosives may be divided into two main classes, explosive compounds and explosive mixtures.

Explosive Compounds are substances of definite chemical composition, such as nitrocellulose, nitroglycerine, and fulminate of mercury, and are used in the pure form in only few cases.

Explosive Mixtures are mixtures of some combustible, which may or may not be an explosive in itself, with an oxygen supplier, the latter being usually a nitrate, chlorate, or perchlorate. Other oxidizers are available, and used in a few cases.

A third class might be added, consisting of mixtures of explosive compounds with addition of inert materials. Cordite and blasting gelatine belong to this class.

Nitrate Mixtures.—Any one of the nitrates can be used as an oxygen supplier for an explosive mixture. *Potassium nitrate*, KNO_3, is best known and most used. It contains 40 per cent. of its weight of available oxygen, is not at all deliquescent, and mixtures containing it require no special protection from the atmosphere, except in tropical climates.

Sodium Nitrate, $NaNO_3$, is a much cheaper salt, and contains 47 per cent. of available oxygen. But it is very deliquescent, and cartridges of explosives containing it must be made moisture-proof. In spite of this defect it is largely used in mining explosives of the cheaper variety.

Ammonium Nitrate, NH_4NO_3, contains only 20 per cent. of available oxygen, and is very deliquescent, but otherwise possesses many good qualities. All of its products of explosion are gases, and are available for doing work, unlike the metallic nitrates. It is also an explosive in itself, and can be detonated into nitrogen, oxygen, and steam, with evolution of heat.

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In its natural form it contains water of crystallization. This is driven off by heat, and the substance packed in barrels in the form of powder. If this is heated above 32° C. it changes its crystalline form and volume; the small amount of water which it still contains combines with the crystals and acts as a cement, so that the whole sets into a solid block. The same thing occurs with ammonium nitrate explosives, which should be kept below this temperature, as when they set solid they cannot readily be detonated.

Barium Nitrate, $Ba(NO_3)_2$, contains 31 per cent. of available oxygen, and is used in some mixtures. This, and others which give colour to flames, are used in compositions for coloured flares.

Ammonium Nitrate Mixtures.

Ammonal.—One of the best known and most used of the ammonium nitrate mixtures is ammonal, in which use is made of the great heat given out by the oxidation of aluminium. A mixture of Al powder with the theoretical amount of ammonium nitrate for complete oxidation would contain 81.6 per cent. of NH_4NO_3. It would yield 1,578 cals. per gram—nearly as much as nitroglycerine—and 682 c.cs. of gas. But such a mixture is difficult to detonate, and charcoal was added to make it more inflammable. One such ammonal made in Austria and used by Austrians as a shell filling has the following composition :—

Ammonium Nitrate	81
Aluminium powder	15
Charcoal	6

The addition of di-nitro-toluene, or tri-nitro, makes detonation more certain, and the new ammonals contain one or the other.

Military Ammonal has the following composition :—

Ammonium Nitrate	65
Tri-nitro-toluene	15
Aluminium (coarse powder)	16
Aluminium (fine powder)	1
Charcoal	3

It is a coarse black powder. Very insensitive, and cannot be exploded by the shock of a bullet or application of flame. When heated strongly it inflames and burns. When thrown on a red-hot surface it flashes off. It requires fulminate detonators and strong tamping for best effect. With large charges several detonators fired simultaneously are advisable. All cartridges must be hermetically sealed to preserve them from moisture, which quickly ruins ammonal. The velocity of detonation is about 4,000 metres per second, and the effect intermediate between that of gunpowder and dynamite. Power 3 to 4 times that of gunpowder.

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Enormous quantities of ammonal are now used in military operations. For charging grenades and bombs. For military land mines; some of our biggest and most successful mines were charged with ammonal. It is not now used as a shell filling.

In the charcoal ammonal a portion of the aluminium is fine powder to assist ignition, and the remainder coarse to resist oxidation on keeping.

Sabulite.—This is an explosive resembling ammonal, but calcium silicide, Ca_2Si, an electric furnace product, takes the place of the aluminium. Its composition is as below:—

Ammonium Nitrate	78
Tri-nitro-toluene	8
Calcium Silicide	14

It is a granular, dark greenish-coloured powder. In properties it resembles ammonal, but is more sensitive. It is also used for mines, bombs, and grenades. It is detonated in the same way as ammonal, and has about the same power.

Bellite is one of the earliest ammonium nitrate explosives. It has the composition:—

Ammonium Nitrate	83
Di-nitro-benzene	17

It is used to some extent for mines, grenades, and bombs. It is detonated in the same way as ammonal and sabulite, but is less powerful.

The products of detonation of all the above are non-poisonous gases.

Amatol.—This is a mixture of ammonium nitrate and T.N.T. in various proportions, which is now of great importance. T.N.T. does not contain enough oxygen for its complete combustion, and although the addition of ammonium nitrate increases the weight of the charge the increase of the heat given out more than compensates for this. The equation representing complete combustion of the T.N.T. is as follows:—

$$\underset{2\times227}{2C_6H_2(NO_2)_3CH_3}+\underset{21\times80}{21\,NH_4NO_3}=14\,CO_2+47\,H_2O+27N_2$$

$2\times227=454$ grams of T.N.T. require $21\times80=1{,}680$ grams of NH_4NO_3 for complete combustion. Such a mixture would contain 78.7 per cent. of NH_4NO_3 and 21.3 per cent of T.N.T. It would give 1,042 calories and 892 c.cs. of gas per gram, with a coefficient of 929, whereas pure T.N.T. gives a maximum of 732 calories and 987 c.cs. of gas per gram, with a coefficient of 722. Various mixtures are now in use, the proportion of ammonium nitrate to T.N.T. being given as a fraction. Thus—90/10, 80/20, 50/50, 40/60. Some of these are given fancy names.

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The higher the proportion of ammonium nitrate the greater the difficulty of detonation, and the difficulty increases when they are melted and cast into solid blocks or slabs, as is necessary for shells. Hence, the higher proportions are used in the form of powder for bombs, grenades, and mines, and detonated by fulminate detonators. The others, used for shell filling, are detonated by special methods, and will be referred to later.

All varieties of amatol are powerful H.E.; velocity of detonation about 4,500 metres per second. All are spoiled by moisture and must be waterproofed. All are practically smokeless. The products of detonation of the mining varieties are CO_2, H_2O, and N_2, and are non-poisonous.

The Germans also use ammonium nitrate explosives. Two used extensively for land mines and mined traps in evacuated territory are *Donarite* and *Westphalite*, both industrial explosives.

A typical Donarite has the composition :—

Ammonium Nitrate	80
Tri-nitro-toluene	12
Nitroglycerine	4
Flour	4

There are several varieties of Westphalite. One has the composition :—

Ammonium Nitrate	70.5
Di-nitro-toluene	11
Flour	2
Sodium Chloride	16.5

The NaCl is to diminish the temperature of explosion so as to make it suitable for coal mines.

These explosives are made into slabs, which are wrapped in paraffined paper. Several are packed in a tin case hermetically sealed, and form a cartridge. Holes covered with waterproof paper are left in the tins for the insertion of detonators.

There are scores of similar explosives, and several varieties of each, used for industrial purposes, the weaker and slower varieties being purposely modified for special cases.

All ammonium nitrate explosives must be packed air-tight to prevent entrance of moisture, which quickly ruins them. When heated to a temperature of 32°C. the nitrate changes its crystalline form and increases in volume. This change, aided by the small amount of moisture which is always present may cause the charge to set into a solid block which is almost impossible to detonate. Hence, ammonium nitrate explosives should be kept as cool as possible, and never exposed to direct sun rays.

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Other Nitrate Mixtures.

Gunpowder.—For centuries gunpowder was the only explosive, and it is still the best known. It has lost all of its importance as a propellant for use in guns and rifles, yet, owing to the many excellent properties which it possesses, it has at present a greater number of military uses than any other explosive.

Black gunpowder has the following composition:—

Saltpetre, KNO_3	75
Sulphur	10
Charcoal	15

When gunpowder was of the first importance the charcoal was mostly made from willow, alder, and dogwood, as these were found to be best, but at present birch, poplar, and even common charcoal are found to be good enough for many of the purposes for which gunpowder is now used. The sulphur and saltpetre must be pure; the charcoal is the only variable constituent.

There is nothing new in the method of manufacture, and no details need be given. The various processes are to ensure:—(1). Thorough incorporation of the ingredients. (2). Fairly high and uniform density. (3). Uniformity in the size of the grains, these being well polished to give them good keeping qualities. The incorporation used to last from 4 to 8 hours, but has now been considerably shortened for the inferior qualities.

Gunpowder is used extensively as an auxilliary to the more powerful explosives. It is quite permanent, when kept dry, but moisture completely spoils it. It has a high ignition point, 300° C., but then ignites readily, and burns quickly and with certainty. It is this certainty of action which recommends it for many purposes. It is comparatively weak, 57 per cent. of the products being solids, mostly K_2CO_3, K_2SO_4, and K_2S_2. These form a smoke cloud, but this is often an advantage for observation purposes.

The following are some of its present-day military uses:—

As Igniting Primer for Smokeless Powders.—Cordite and N.C.T. powders do not ignite readily, especially when in thick sticks, and a powerful flash is required. In separate ammunition, where the charge is in a fabric bag, a packet of gunpowder is fixed at one or both ends of the charge. In fixed ammunition for Q.F. guns a percussion primer is screwed into the cartridge case. This contains a percussion cap and 1 to 2 ozs. of gunpowder. The flash from the powder ignites the explosive charge with certainty. It is also used in friction tubes.

As Bursting Charge for Shrapnel.—A shrapnel shell is filled with bullets, and the head is lightly attached. The bursting charge is only required to blow off the head and liberate the bullets. Little power

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is necessary, but it must act instantaneously. A charge of gunpowder in a cup at the base of the shell is found to answer best.

As Time Fuze Composition.—The timing rings in fuzes which regulate the moment of the burst are filled with compressed powder. Under atmospheric pressure this burns with great regularity.

Gunpowder is also used for blank charges, for land mines, and has many other minor uses, where certainty of action is of more importance than power. It forms the core of safety fuze.

Picric Powder (also called Brugères powder) is a mixture of finely divided ammonium picrate with potassium nitrate, in the proportions of 43 to 57. It can be detonated by moderate percussion. It is difficult to ignite, but a flame will do it, and it requires good tamping to obtain the full effect. It has about twice the power of gunpowder.

When exploded in a confined space the explosion may proceed to detonation, and the wave set up will extend to picric acid. For this reason picric powder, both in powder form and compressed pellets, is used to detonate lyddite shells.

A less sensitive modification of picric powder, in which the potassium nitrate is replaced by ammonium nitrate is used for charging bombs, etc.

Tonite.—This is a mixture of about equal weights of barium nitrate and guncotton. It is a powerful H.E. with great shattering power, and was formerly much used as a blasting powder. It is used in sound signal rockets.

Smoke Compositions.—There are many, some depending on the incomplete combustion of carbonaceous matters. Others consist of nitrates mixed with aluminium or zinc, the oxide of the metal forming a white cloud. Packets are introduced into some H.E. shells to show the position of the burst.

Mixtures of nitrates and chlorates are used in various compositions for flares, and will be referred to later.

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WEIGHTS AND MEASURES.

"B.B.E." writes :—With reference to the article appearing in the *Journal* on the subject of "Weights and Measures" with regard to Field Company vehicles, I think I can offer a few explanations of the discrepancies.

Tool Carts and R.E. Limbers.—The Organization of a Field Company does not work in with the loading laid down in the Handbook. For example, sections of a Field Company must be able to move independently at very short notice. Now the loading tables show all the Cooks' gear on the Cooks' Cart, and the subdivision of Cooks' gear, rations, etc., on the detachment of a section (which might have to take place on the line of march) would invariably lead to confusion and someone going supperless. In consequence it is customary in a large number of Field Companies to put the section Cooks' gear on to the section limbers, and to place the explosive, etc., displaced on to the tool cart. This would lead to a large discrepancy in the weights of these vehicles.

Pontoon and Trestle Waggons.—The weight of these waggons when stripped has been increased by about 1,000 lbs. by the fitting of heavier wheels and all the iron-work "gadgets" for M.T. traction. Any further increase in weight in these vehicles, and also in the G.S. Waggon, can be traced to the fact that Field Companies on service have to carry stores for which little or insufficient allowance is made. Such are :—

(*a*). Officers' Mess Gear.
(*b*). Office Stationery.
(*c*). Chaff Cutter.
(*d*). Picket Line Gear.
(*e*). Horse Rugs and 2nd blankets (in winter).

I hope these hasty notes will be of some service in elucidating this matter, which are the result of three years' service with an Old Army Company.

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MEMOIR.

BRIG.-GENERAL DUNCAN SAYRE MacINNES, C.M.G., D.S.O., ROYAL ENGINEERS.

FEW, if any, among the many valuable officers who have fallen in the present War with Germany have given greater promise from past distinguished service, ability and personal character, of rising to yet higher distinction in their profession, than Brig.-General Duncan MacInnes. Born in 1870, he was a younger son of the late Hon. Donald MacInnes, of Hamilton, Canada, who, moving from Scotland to the Dominion in early life, became a Member of its Senate, and Mary, daughter of the late Sir John Beverley Robinson, Bart., C.B., Chief Justice of Upper Canada (now the Province of Ontario).

Intended originally for the Navy, he spent some time upon the *Britannia* Training Ship, but afterwards entered the Royal Military College at Kingston in Canada, his father having ultimately determined upon a military career for him. From this he passed out at the head of his year, obtaining a Commission as 2nd Lieutenant in the Corps of Royal Engineers, on 16th July, 1891. On 18th July, 1894, he became a Lieutenant, on 1st April, 1902, a Captain, in 1911 a Major, in 1915 a Bt. Lieut.-Colonel, and at the time of his death held the rank of Brig.-General in the Army.

He had seen much active service. In the expedition to Ashanti of 1895–6 he was Honourably Mentioned and awarded the Star issued for that Campaign. Later, while a Lieutenant, R.E., he was employed upon the erection of a fort at Coomassie, the capital of Ashanti, for the defence of the garrison of that place, and here it may be mentioned that in plan and execution this work reflected great credit upon him and all others concerned in its design and construction. When in 1900 a garrison was for some time besieged in this fort by 15,000 Ashantis, it was successfully held, until relieved by a force under Colonel—now General Sir James—Willcocks, who, in *From Kabul to Kumassi* thus alludes to it:—"Nothing astonished me more during my three years in that country (West Africa) than my first sight of this fort, standing out boldly on a wide open plain. Store-rooms, ammunition chambers and many quite modern improvements make it the best defensive post I saw in West Africa."

Lieut. MacInnes also acted for a time as Resident at Coomassie.

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Brig.-General Duncan Sayre MacInnes, C.M.G., D.S.O.,
Royal Engineers.

From a Photo by Amy Cassels, 67, New Bond Street, W.

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In the South-African War he performed specially valuable services between February and May, 1900, in the Orange Free State and particularly in the Defence of Kimberley. Here he was employed upon Corps duties and in addition as Staff officer to Colonel Kekewich, commanding the defence, who, in his Report of 15th February, 1900 (enclosed to the Secretary of State for War by Lord Roberts in his Dispatch of March 20th), thus alludes to him :—" Lieut. (local Capt.) D. S. MacInnes, Royal Engineers, worked out most carefully and constructed with marked ability and success, the Engineer operations for the Defence of Kimberley. He is a real hard worker, full of zeal, energy and resource. Wherever he went he inspired confidence. On Bt. Major Turner taking over command of the Mounted Troops, Capt. MacInnes relieved him as my Staff Officer, and I cannot speak too highly of the manner in which he carried out his heavy and very responsible duties, both within the fortress and in connection with sorties, reconnaissances, etc." After the relief of the town, a distinguished officer, who had known his father in Canada, thus wrote to him from Kimberley : " You will, I know, be proud to hear the very high character for gallantry, tact and readiness of resource, which your son in the R.E. has won for himself. His praises are in every one's mouth and I am told that the success was, in a large measure for so young an officer, due to him." No tributes to the value of his work in the Defence of Kimberley could well be higher than the above.

Between May and November, 1900 he was further engaged in operations in the Orange River Colony, and between November, 1902, and December, 1904, acted as Assistant Director of Works to the South African Constabulary. For his services throughout the War he was twice mentioned in Dispatches (in 1900 and 1902), received the Queen's Medal with three clasps, the King's Medal with two clasps, and the D.S.O.

Between 1905 and 1908 he was employed upon the Staff in Canada, first as D.A.Q.M.-General at Halifax, Nova Scotia, and afterwards as D.A.A.-General with the Canadian Dominion Forces. Much work now devolved upon him in connection with taking over the defences of Halifax by the Dominion from the Imperial Government, in drawing up schemes for future defence, and training troops for defensive duties. A general officer under whom he worked at this period writes of him as follows :—" I found his knowledge of both the Regular and Dominion Forces of the greatest use to me—his tact and ability were very marked." And another :—" His work in adapting the Defence Scheme for Halifax, to the altered conditions, was very valuable. I had many opportunities of judging of it. I then formed a high opinion of his abilities as a soldier, combined with his tact and other good qualities as a Staff officer, so that I was not surprised when a year or two later, an officer holding a very high

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position in England spoke of him to me as one of the best Staff Officers he knew. He had the quality of thoroughness in a high degree."

From Halifax he went to Shorncliffe, as Major, R.E., in charge of works, which included the building of the Women's Hospital at that Camp, and from thence to the Staff College.

In 1910 he was gazetted a General Staff Officer (3rd Grade) under the Director of Military Training at the War Office, being in 1912 employed as Secretary to the Royal Flying Corps Committee, appointed by the Committee of Imperial Defence. The result of this Committee led to the formation of the Royal Flying Corps, which has since developed into the Royal Air Force. He also took an important part in the reorganization of the Army Signal Service.

Later (in 1913) he was appointed as G.S.O., 2nd Grade, to the Staff of the Staff College and in 1914, upon the outbreak of the War with Germany, proceeded to the Front in France.

After taking a part in the Retreat from Mons, for which he earned the personal thanks of one in high command, he was wounded in November, 1914, when Major in charge of a company of Royal Engineers with the 9th Division, and he returned then to England. The wound, which was caused by a bullet, permanently interfered with the free use of one or two of the fingers of his right hand.

In 1915 he served at the War Office as Assistant Director; and in 1916–17 as Director of Aeronautical Equipment and, during his tenure of this post, more than once crossed the channel by aeroplane, visiting the Headquarters of the Flying Corps and of the Army in France.

The Aeroplane of 29th May, 1918, thus refers to his services in association with the Air Force:—"As Director of Aircraft Equipment, General MacInnes had to face a most arduous task. It fell upon him to evolve from the formless muddle of 1915, some regular scheme for organizing and increasing aircraft production, simultaneously. All those who served with him at that period bear witness to his unflagging zeal and the amount of personal effort which he expended. If hard work on the part of one man could have produced the necessary aeroplanes and engines, General MacInnes would assuredly have obtained them. Despite an infinity of natural obstacles and personal hindrances he succeeded in effecting remarkable increases in output and at the same time he won the personal affection of all those who worked with him, or under him. The intensity of his efforts nearly broke down his health, but before he left the War Office to take a command in the field he had done much spade work, which afterwards proved of high value. . . . His name deserves to live in the history of Military Aeronautics as one of those who helped the Royal Flying Corps in its blackest days."

One who worked much with him at this period, and is now a General Officer, writes:—"He joined the Military Aeronautics

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Directorate at a time when very little had been done and there was no organization to meet what he knew was to be, a gigantic force. He never spared himself. I think it is only those few people who worked with him in the early part of the War who really recognize how much the Royal Air Force owe to his untiring energy and splendid qualities. I never met a man who worked so hard and so conscientiously, and this in spite of the fact that he was suffering from the effects of a wound, and of general bodily ill-health, brought on by the trying time he had had during the Retreat."

In March, 1917, anxious to see further active service at the Front, although it involved the relinquishment of his rank of Brig.-General, he went out again to France to perform the duties of Commanding Royal Engineer to the 42nd Division and from thence, after nine months, was appointed Inspector of Mines at Headquarters with the rank of Brig.-General. On 23rd of May, 1918, while upon active service at the Front on this duty, he was killed, and was buried in the Military Cemetery at Etaples, close to the sea, on Saturday, May 25th.

During the present War he had been twice mentioned in Dispatches, received the Star for Mons, the C.M.G. in 1916, and the Russian Order of St. Stanislaus, with the French " Croix d'Officier " of the Legion of Honour, in 1917.

Many have been the warmly appreciative letters written at various times, by all ranks of his brother officers, senior and junior, as well as by others, alluding to his services. Several touch upon his great gallantry in the field, others upon his sincerity and unselfishness, all upon his capacity, energy and devotion to duty.

From a few only I can quote here, but I do so from some below, because I feel that they give a better and clearer idea of what he was as a soldier and a man, than could any words of my own, and show that he possessed, to an extent that was marked indeed, high qualities, together with those personally attractive ones that gained for him, not only the confidence, but the affection of men.

From a Field Officer :—" It has been a terrible blow to us all to lose a man of such ability and so splendidly conscientious in his work. He was one of the very bravest and most chivalrous characters I have ever known and he was universally beloved by all who met him, from the highest in command to our car drivers, servants and orderlies. Everyone felt strongly drawn to him."

From a General Officer under whom he immediately served :—" He was my right-hand man and never failed me. We all loved him. . . . He was so tremendously brave at Nieuport and other nasty places, a well-known figure in his Division and perfectly splendid at his work."

From a Field Officer :—" He quickly won the admiration of all of us from his gallantry, unbounded energy and kind consideration for others, no matter what rank they held." And (referring to the

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dangerous work of repairing dams, which the Germans kept repeatedly blowing down) " On one occasion when we were working he insisted upon taking one of the shifts, which was most encouraging for the men and enabled the job to be completed.

But I avoid accumulating further tributes to his memory, and what he accomplished. Above anything that he ever did or said, it was his sterling character that so impressed and attracted all who knew him. Of a buoyant, bright and cheery nature he was enabled to get through successfully a heavy amount of work, although at times of pressure, necessarily frequent under the strain of War, he was disposed to overtax himself. He was never so thoroughly and entirely happy as when in the field, occupied in the duties of the Corps he was devoted to—the Royal Engineers—and death while upon active service came fittingly to him.

By disposition it can be truly said that he was retiring, and certainly the reverse of what is termed a " thruster." Ambition, in its selfish sense, all effort to push himself, all undue striving for honours or rewards, were foreign to his nature, although, in his comparatively brief career, he had earned many medals and decorations.

Just before his death he was in especially good spirits at having successfully completed a task in which he had been taking a keen interest, and was joyfully looking forward to the prospect of a few days' leave to England and then to employment upon other duties after his own heart.

To the Service, to his family, and to his numerous friends he is a very great loss.

In 1902, General MacInnes married Millicent, daughter of F. Wolferstan Thomas, Esq., and he leaves behind him one son (now at Eton) and one daughter.

C.W.R.—R.B.

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NOTICES OF MAGAZINES.

REVUE MILITAIRE SUISSE.

No. 4.—April, 1918.

Some Political and Juridical Aspects of the Great War.

The original article consists of the address given to the Lausanne and Geneva Sections of the *Société suisse des officiers* by Capt. Cuno Hofer of the Swiss Cavalry; in it he points out that the Conflict which broke out in 1914 presents, from the International standpoint, problems in the domains of Politics and of Law. The question at once arises whether there is indeed any such thing as International Law, or is it after all but a chimera? The author of the original article is of opinion that to postulate a state of affairs in which the relations of the individuals and peoples of the different States, and, indeed, that of the States between themselves, were not regulated by governing principles would be to attempt to create a situation which is absolutely inconceivable. Dependence on law has obtained a strong hold on human nature; even amongst a community of brigands, the notion of law is manifest as a governing factor, up to a point, in their relations amongst themselves. The conception of law is inherent in the human race. Juridical relationships were first established among *peoples* at the time that they ceased to wage eternal war on one another and a state of peace was, in consequence, brought into existence—a highly abnormal condition of affairs at the period when man was still a savage. During the course of the centuries which have followed since then a body of governing principles have been developed and have been accepted as a code of International Law; first of all, the early traditions and customs became law, and on this basis has been built up that ever-growing body of law much of which has been incorporated in International Treaties. States found it convenient to recognize the value of giving the force of law to certain rules to which binding effect had been given by the sanction of long-continued voluntary observance. It is alone owing to the recognition of such a code that international, political, economic, commercial, intellectual, and social relations between the peoples of different States have been rendered possible.

But a law of this nature has its limits; it does not embrace within its folds the entire life of a State, in the same way that the municipal law of a State does not govern the whole life of a subject thereof. In spite of the Civil Code, the Law Merchant and the thousand-and-one supplementary laws, a subject has his being in a free space, wherein he may derive benefit from or abuse his liberty; in each case the individual's character, his tastes and his education determining which of these alternatives will result from his course of conduct.

The free space, outside the limits of International Law, in which

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States are at liberty to roam are still more vast than that available to subjects; juridical control is, in the case of States, more incomplete; in a word, the laws that hedge them in are less numerous. Another difference should be noted; the subject who breaks the laws of the land finds himself, as a rule, in collision with the "sanction" of the competent authority. The subject continually runs a risk that a tort may be committed to his injury, but in such a case the police will come to his assistance and a judge will punish the tort-feasor. In the terraqueous globe in which States form the international community, there exists neither police, nor "sanctions," nor any other judge than that of public opinion, which may be more or less harsh, more or less impartial. Under such circumstances, therefore, should a State be affected by a tortious act committed to its detriment, a difficulty lies in obtaining redress by judicial process. If the wrongful act in question is not of a serious nature the assistance of diplomacy and the aid of the most elementary rules of equity may provide the remedy necessary; or a submission in respect of the dispute or difference may be made to an arbitral tribunal and the difference composed by the award of such tribunal. Whatever course is adopted to obtain a remedy, where the matter in dispute does not involve an important principle, every effort is made to prevent a rupture of peaceful relations.

However, when differences arise on questions held to be of vital importance, States are apt to stand on their dignity; they then parade their *Sovereignty* and refuse to recognize any Will but their own. Such was the attitude Austria-Hungary took up towards Serbia in the summer of 1914. It is in circumstances of this kind that International Law is, so to speak, abrogated; then it is that the peaceful *régime* of law has to yield place to the sway of brute force. The mediation of friendly Powers, arbitration, International Commissions, at such a time, severally cease to inspire confidence as a means for attaining human justice, eithe- because one of the parties to the quarrel may wish to display its prodir gious strength or because it may consider the moment opportune to realize some vast design. Once its own *Sovereignty* is thus invoked by a State it enters into boundless space, the sphere of Politics.

Some there are who talk of the force of law and the "law of force." The force of law is a conception understood by all intellectual beings, but the expression "law of force" conveys nothing definite to any one. Nations can compose their differences either by force or by law. The choice of one of these means involves the rejection of the other. A private individual who is wronged by another may seek his remedy at law or may personally adopt measures against the wrong doer; by adopting the latter course, however, he would place himself outside the pale of the law. So is it in the case of a State, but with the difference that the use of force by a State is not considered, according to the human code of ethics, unlawful.

The notion of the "law of force" has been invented to mislead and to cause confusion where clear conceptions should prevail. The question for future decision is whether Law, based on juridical principles, shall some day take the place of Force, which, as exemplified in its application for the waging of war, involves a negation of Law. At the present

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time all the essentials to bring about this order of things are conspicuously absent; namely, the law, the tribunal and, indeed, the moral Will necessary to create them.

To the non-existence of organized international justice is it due that the Chief of the State and the Leader of an army have, at all times, invoked the Divine aid in favour of their cause. The adoption of such a course has doubtless been, in the first place, a question of faith, but it arises also to some extent from uncertainty as to the issue and from the anxieties connected with the enterprise on hand; personal conviction and the use of force always come into play in the absence of the procedure of established Courts of Justice. When in such a dilemma those in authority are disposed to seek support from a Supreme One. If Wilhelm II. has done so with much persistence, it can but be because his need has been intensely great.

The prayer before battle of *der alte Dessauer*, a contemporary of Leibnitz and the real reformer of Frederick the Great's army, best expresses the state of mind of an enterprising leader: "Good Lord, send down Thine assistance to me. But if Thou art not willing so to do, nevertheless withhold Thine aid from mine enemies, rogues that they be." Voltaire has recorded his views on the subject in the following terms:—"The marvellous thing about this infernal business (*i.e.* war) is that each chieftain of murderers calls down blessings on the standards of his followers and solemnly invokes the aid of the Almighty before proceeding with the task of exterminating his neighbour." A similar sentiment is contained in the following couplet:—

"On ne peut ni voler, ni violer son monde,
Ni massacrer les gens, si Dieu ne nous seconde."

The situation is in no way changed; it remains the same to-day as in the centuries past. In the days before Voltaire's time, in those that have followed even unto this day, with or without God, the domain of international politics gives free scope to speculations of the widest range, those that are the most egotistical and those that are the most human.

A reference has already been made to the "law of force"; therefore, a word or two on the "Divine law," a subject that has also given rise to some confusion, may not be out of place. The popular view is that the titular qualification of the Prussian Sovereign which runs:—"Wilhelm II., by the Grace of God, King of Prussia" amounts to a claim on the part of the German Emperor that he is a direct representative of the Almighty. Naturally, no Swiss officer would think of introducing himself as "Alfred Cornu, by the Grace of God, Lieutenant of Engineers"; it is common knowledge that the commissions of Swiss officers do not bear the Sign Manual of the Creator, but are signed by Cantonal or Federal Magistrates. In the case of the King of Prussia, on the other hand, the very serious difficulty is met with of ascertaining definitely whence he derives his powers, the rights and privileges enjoyed with the Crown. It is beyond dispute that the powers, rights and privileges in question have not been conferred by the Prussian people; on the contrary, it is the King who has *granted* a constitution to his people whereby he has *condescended*, by a personal act, to limit his

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indisputable powers and rights. The Constitution of Prussia contains no provision, of a lawful kind, under which the Hohenzollerns could be deprived of any of the rights pertaining to the Prussian Crown. Thus it is that to the question:—"Whence are these rights then derived?" historic tradition replies:—"From God." In the absence of some other reliable explanation, juridical doctrine has admitted this reply and accepts the *fiction* that the Hohenzollerns reign in Prussia by the Will of God.

Rousseau's declaration that the State owes its origin to the Social Contract also involves a *fiction;* the declaration amounts alone to his political conceptions of an ideal. The origin of the State cannot be ascertained by any process of reasoning from theoretical premises. The existence of the State is inconceivable apart from juridical order (which forms one of the elementary constituents of the State) and, on the other hand, the existence of juridical order is inconceivable apart from the authority derived from the State; this leads to an argument in a circle. Rousseau's declaration expresses admirably a spiritual conception of human communities; a conception to which weight is given by conviction, but the *fiction* remains.

The fiction employed in the German Science of Constitutional Government in order to explain the *origin* of regal power in Prussia may have been accepted in that country either because it translates into words the sentiments of the populace on the subject, or because that Science is incapable of supplying any other explanation owing to the impossibility of depriving the King of his powers in a legal manner. It would be wrong, however, to confound this theory with the ancient theocratic theory of the Eastern Empires according to which the State is a creation of the Almighty and the Monarch his representative, and therefore a sacred person, invested with divine powers.

A State is mistress of its own destinies; it possesses sovereign powers and recognizes none other as its superior; it need listen to no counsels of wisdom, nor accept decisions based on international justice, which after all is but the justice of human minds, therefore suspect.

The State consequently possesses very considerable liberty in that boundless sphere of its activities, its politics, which may be defined as the art of handling the affairs of State, of regulating its life, of directing its effort towards definite aims. Policy consists in the sum of the aims a State may be pursuing; that is to say, it represents the mind and the individuality of a State. Should the policy indicate that it would be in the interests of the State to establish economic relations with certain other Nations, law enables it to realize this purpose by means of a formal Treaty of Commerce ratified in due form. Should the policy dictate that the War Establishment of the Army ought to be increased in order to accomplish some great design; law brings into existence a new military organization. Inversely, law demands that the terms of a treaty which has been entered into and duly ratified shall be strictly observed; but policy may take up the attitude that only if it should be opportune to do so ought the provisions of the treaty to be complied with; momentous events may follow from the decision taken on the dictates of policy.

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But whatever may be the measures that policy may impose on a State, nevertheless law never ceases to be operative to some extent; as already stated, law is inherent in human nature. Therefore when a State has broken off relations with another and cut all juridical ties which have bound it to its neighbour, in a word when it declares war, at that instant another law comes into force; the *law or customs of war*.

This notion raises a smile; we have all been made familiar during the past three years with the devastated regions of Belgium, the mutilated tracts of France, both by the word pictures and by the photographic reproductions appearing in the Press. The wholesale destruction of a vast countryside, the terrible cruelties inflicted on a peaceable civil population have, it is urged, been necessary in the military interest. True, the situation thus created may have caused the Western Allies some embarrassment from a military point of view. But, why stop at what has already been done? Why not, asks Capt. Hofer, push the principle further? The Germans are short of provisions, and, yet, they are giving shelter to and feeding some thousands of prisoners; every day many tons of supplies, which might help to alleviate the distress of the German people, are utilized for nourishing foreigners and the Fatherland's enemies resident in Germany. The question is asked:— Why does not Germany impale these thousands of men? Why does she not drown them in the Rhine?

Clearly there must be some limit beyond which even the most depraved soldier cannot go, at this point it is that the *law of war* comes into play; a law which consists of a collection of rules of equity and of honour that come into force at the instant that a state of peace makes way for a state of war. This law was born on the field of battle and has a long history. All that need be said here is that with the progress of civilization two principles were established: firstly, that war is a relation between State and State, and not that between one individual and another; consequently, the idea was developed that the peaceful citizen ought not to be directly affected by war; that he must suffer indirectly therefrom unfortunately is inevitable. Secondly, that all useless cruelty ought to be avoided, since fighting men are not a lot of wild beasts let loose. Rousseau first crystallized these principles, which had been propounded in indefinite language by doctors of international law, into formulæ containing precise terms. By degrees these formulæ were incorporated into the military codes of civilized nations, elaborated and expanded to meet the various requirements of the situations considered likely to come into existence. Finally, a period was reached when the military codes of the civilized Powers appeared to be based on the same principles, more or less; in consequence, steps were taken to embody the instructions contained in the several military codes in International Conventions, that is to say, to transform these instructions into a fixed law, to be binding on all adherents to these Conventions.

At the time that this law was being elaborated at Geneva and at The Hague by distinguished soldiers, politicians and savants every care was taken to ensure that the text of no juridical rule should violate the principle that nothing should be done to interfere in any way with the effectiveness of military action, the essence of which, it was recognized,

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consisted in violence and must continue to remain so. At the same time it was admitted that restrictions must be imposed on the civil population in relation to its conduct towards the soldier ; the *franc-tireur* was warned off. The essential principles of the law of war represent the maximum limits of the surrender which the civilized soldier should be called upon to make in respect of his right to exercise violence to attain his ends.

The Germans have excused their misdeeds and crimes on the Somme on the grounds of " military necessity " ; as already stated a justification of this nature can be made to cover the most extreme excesses and acts of depravity. Of course, there are occasions when a soldier may *suddenly* be faced with a situation in which he has to decide whether he shall conform to the *law of war*, and thereby court the failure of the special task he has on hand, or whether he will violate the *law of war* in order to promote what, under the circumstances, must necessarily be the superior interests of the army of which he is a member.

On such an occasion, the soldier must be guided in the action he may take by his sense of responsibility ; his own temperament will determine how he obeys the promptings of his conscience.

Although in the present Conflict innumerable violations of the *law and customs of war* have occurred, it must not, nevertheless, be thought that the whole of the provisions of this code have been a dead letter. Undoubtedly, the experiences of many an unfortunate combatant would have been more intolerable had no such code existed ; to this extent it has been an ameliorating influence.

The events which have succeeded one another in Europe since July, 1914, fall under one or other of three heads, politics, law or despotism. The most important of these heads is that which constitutes the political domain, one covering a very vast field. Those individuals who play the most active part in this domain hold most diverse views regarding morality and justice ; modern communities, however, keep their political leaders within certain moral bounds. To enter into a discussion as to what is moral in politics, as to what comprises ideal justice is profitable only so far that thereby we learn how vague, how complex is everything in this domain. Politics possesses two schools, the idealistic and the realistic. At the present moment the nations of the world are grouped round one or other of these centres. In the belligerent countries too, the people are divided into Liberals and into militarists; into apostles of the new era attached to the idea of a juridical organization of nations and into politicians of the old school opposed to progress in the world.

Treitschke's views on morality in politics are quoted by Capt. Hofer. This philosopher, as might be expected, cannot tolerate the idea that any person, howsoever high his position, should have it in his power to impose obligatory rules on the State ; doctrines founded on logic have always, he says, had to give way to the realities of life. The greatest moral duty of a State, is according to him, the maintenance of its powers. Treaties are all entered into on the understanding, he declares, that they shall cease to be operative as soon as the circumstances under which they were ratified have altered. A large number of German savants subscribe to these views. To the end of the world, says Treitschke, nations will

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have to look to armed men for the protection and the safety of the State, and therein lies the *sanctity* of war.

It is to the political ambitions created in vast populations by philosophies constructed by magniloquent professors that a war spirit was engendered in Central Europe. It is under the auspices of such politics that the present war was declared. When this step was taken the German Chancellor found himself in a tight corner; on the one hand, there was a Treaty clear and precise in its terms, which demanded that the neutrality of Belgium should be respected (a serious juridical hindrance to the complete liberty of action ordinarily enjoyed in the domain of politics), on the other hand, there was the urgent demand of the Great General Staff, which insisted that German Armies must march through Belgium to make success sure; that is to say, to ensure the safety of the State. The Chancellor had to weigh a formal law, a solemn obligation in one pan of the balance against the interests of over 60 million souls in the other pan. It was a question of a choice between respect for law or for the supreme interest of a cause. His conscience could alone guide the Chancellor to a decision; this conscience had naturally been moulded by the political education received during a long career in the public service. Von Bethmann-Hollweg yielded to what has been referred to as the law of necessity, reasons of State; in doing so he violated the *law*. Treaties providing guarantees have, of course, been frequently violated before; but at no period of International Law had a Treaty been framed under circumstances similar to that providing for the perpetual neutrality of Belgium, or did one possess such binding force both by reason of the status of the signatories thereto and the causes responsible for its genesis. In a word never before had *law* penetrated so deeply into the free domain of high politics, and yet, the law has, in this case, been entirely subverted.

The Belgian affair was certainly one of *law*, because there it was a question of complying with the terms of a formal positive *law*, a solemn engagement duly entered into. But all the other matters; the attitude of Austria-Hungary towards Serbia, the attitude of Italy in coming into the War on the side of the Entente Powers and against her former Allies; the various treaties concluded between the Powers relating to the partition of conquered territory, these are not juridical questions, they are questions relating to political expediency, and do not come within the purview of law. And even when the Leaders of a Nation claim that their actions are dictated not by egoism but by a sense of right, there is still need for caution.

There are naturally inconsistencies in International Law as in all other human institutions; for example, The Hague Conventions provide that a neutral power shall not, during the continuance of a war, be prevented from trading in munitions of war with either of the belligerent parties. It was for this reason that, in the early days of the War, the workshops in the United States of America were openly busy executing war contracts for Great Britain and France. Germany could, of course, have placed orders for war *matériel* in the New World also, but she appears to have shrunk from taking the steps

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necessary to ensure that consignments, which would have had to be transported across the ocean, should reach the Fatherland with certainty and in safety. Although the conduct of the United States of America was in appearance absolutely *unneutral*, nevertheless it was strictly in accordance with the *law*.

Alliances and facts certainly establish *juridical* ties between nations, but, to-day when it is the fashion to display so much regard for law, an exaggerated view is taken of their efficacy and sincerity. The documents published by the Revolutionary Government in Petrograd indicates the extent to which the observance of juridical engagements, hitherto looked upon as sacred, are dominated by opportunism, egoism and political intrigue. Further, it has also to be borne in mind that, in spite of the honesty of purpose of a contracting party, treaties are in reality the most fragile of the works of human hands; the Declaration of London, for instance, was soon rendered a "scrap of paper," willing as was the British Government to give effect to its provisions. There is also the case of the Pact made by the Entente Powers that no separate peace would be made by any one of the signatories to the document in question, and yet, owing to the Russian Revolution the Power in whose interests the Western Allies entered into the struggle has been the first party to the contract which has failed to fulfil its obligations thereunder. The action taken by the temporary governors of Russia represents perhaps an extreme case, nevertheless it does show that in the case of the most formal Pact its complete observance by all the parties thereto depends on a number of contingencies; compliance with the terms of a treaty on the part of a State, a party thereto, is really governed by the *character of its people*, that is to say, it is a question of *morality* and not of law.

Before juridical laws can acquire any real value in governing the international relations of States, it is essential that the principles of morality which are to govern their policies should be framed on similar and standard lines. There is a morality which abhors arbitrary conduct, violence and untruthfulness in international politics; a morality which is opposed to internecine strife between nations. The tendency in the past has been to level down this morality so as to bring it on to the lower planes of the traditions of politics, instead of raising international usages up to the level of the requirements of this morality, and thus to establish the prerequisite foundation on which the structure of a permanent peace between the peoples of the world must rest.

The author of the original article expresses the view that from a historical, as well as from a dogmatic, point of view an international status is not difficult to conceive in which all differences and disputes between nations can be equitably settled by a submission to a properly constituted tribunal rather than by resort to the uncertain arbitrament of the sword. In the same way that the Ordeal of Battle has completely disappeared as a mode of deciding personal quarrels between subject and subject in a State, so it is thought will eventually also disappear war as a method for composing the disputes of States. The political power is fast passing into the hands of the masses, and it is they who will in the future decide directly questions of Peace and War and

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not a few political place-holders as in the past. Their judgment in a given situation will be exercised on vastly different premises to those which have weighed with the trained statesmen of former ages. The democratization of Europe is proceeding apace; one of the most difficult problems of democratic politics is to reconcile the principles of democracy with the power of the State, and, *à fortiori*, to bring into harmony the aims of democracy and war as a means for attaining those aims.

Undoubtedly, new conditions of life are coming into being to govern the relations of the International Family. What the future has in store, however, still remains an unsolvable mystery, which the wisest men of the age are unable to unravel. It behoves us all then to guide our footsteps along the path of progress by that most precious of human instincts: the sense of the reality of things and men.

Doctrines and Duties.

The author of the original article points out that the Great War has given rise to new theories and that situations can no longer be examined by the light of the maxims of former eras only. The General Staffs are at the present time kept busy accumulating by degrees precise knowledge regarding events as they occur, and on that knowledge new doctrines are being formulated.

Some there are who hold that it would be rash to attempt to unravel the enigmas of strategy; the battle they say is an accidental episode and trust must be placed in the offensive spirit of the infantry soldier—who is about to come by his own—to meet the situation and carry the day. The opinion is rightly expressed that no decisive result is likely to be obtained by the present-day wearing-down tactics—the war of attrition—which relies on mere wastage to bring about results that can alone be secured by the adoption of active, as opposed to passive, measures in the handling troops.

The course of events during the past three years has shown that the theories, which had been advanced to prove that modern wars could alone have a duration of a few weeks at most, were constructed on false premises. The constructors of these theories, in many cases, disregarded the influence which the advances made in the technical domain would have on strategy; and, unfortunately, it was thought by those responsible for the direction of the operations of war that to seek advice from technical experts could but mean a confession of ignorance. Why, it is difficult to conceive.

There are sceptics living to-day, who find it difficult to believe that war has, in modern times, become a science. They appear to hold the view that a few "intellectuals" are attempting to resolve movements of war into a few simple arithmetical operations or algebraical problems. Yet the great lesson of the present conflict seems to be that the side, which conducts a war on methodical lines and by the application of systematized knowledge in dealing with every problem connected with State-craft and military operations, has the advantage over the side which proceeds on the happy-go-lucky hit and miss principle of a pre-scientific age.

"Intellectuals," however, are a robust race and are not easily to be discouraged. Many of them have been in evidence during the course of the

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present War. One of the earliest of them to come to notice, since the early days of August, 1914, is Capt. Laffargue, of the French Army, who performed a great service to his profession by the production of his *Études sur l'attaque* based on his personal experiences. He pointed out that the present-day attack had become a matter of fortress warfare. He urged that this fact should be recognized and measures taken accordingly to provide effectively for dealing with the new situation by *orienting the instruction* of troops *entirely from this point of view*.

The acceptance of this "new orientation" brings into prominence certain old dogmas which remain as true to this day as they were in former ages; they relate to the value of sangfroid, discipline, goodwill, power, and knowledge. The acceptance of this "new orientation" involves that the most shall be made of natural advantages which may exist; indeed, the transformation of the *terrain* into an offensive-defensive battlefield.

The nature and character of the attack as carried out in this War appear to have upset some of the cherished notions of teachers of Military Science and Art in Switzerland and to have created some confusion in their ranks. Regret is expressed in the original article that the Swiss General Staff has not issued some official declaration based on the reports received from the military attachés at the Front. It is felt that if an "official doctrine" were to be notified, it would facilitate the consideration of problems connected with the organization of the Swiss Army.

Fault is found with the methods of training in vogue in the Swiss Army to-day. The short courses of instruction, having a duration of barely a fortnight, are thought to be too short.

It is urged that Europe should take a leaf out of Japan's book and follow the admirable customs of the Samurai and adopt their high sense of duty. The duty of a subject is something that cannot be trafficked in; it should be remembered that such as is the *morale* of a people, the same also will be the measure of its victory in a conflict.

In the original article a programme of instruction for recruits (extending over 67 days) is given in some detail; it has been adopted in one of the Swiss schools.

It is said that in Switzerland curses are often levelled at the infantryman for his alleged ineptitude, nevertheless proper steps are not taken to prepare him for a modern battle. It is suggested that the duration of the recruit's training should be doubled and that instruction should be specialized during the extended portion of the training, *i.e.*, some men should be taught bombing, others the use of trench mortars, machine guns, pioneer duties, etc.

The prolongation of the training is a duty imposed by necessity and no good Swiss will shrink from bearing the burden in connection with the fitting of himself to defend hearth and home.

Our Machine-Gunners.

A series of photographic reproductions are published under the above heading and are intended to illustrate the articles on this subject which appeared in the January and February numbers of the *Revue* for this year (*vide R.E. Journal* for June).

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NOTES AND NEWS.

Belgium.—A special correspondent draws a comparison between the military code of ethics of Belgium's soldiers from the Congo with that of the soldiers coming from the banks of the Spree and the Oder, much to the disadvantage of the latter.

Attention is called to the part played by Belgian Colonial troops in the East African Campaign and the eulogies won by them from the British Commanders. Regret is expressed that Belgian Colonial troops were not permitted to take part in the liberation of Jerusalem. Many Belgians took part in and gained distinction during the Crusades; the memory of their exploits still lives in their native land, and it is, perhaps, natural that Belgians should wish again to have the names of distinguished compatriots associated with the present-day achievements in the Holy Land.

There are Belgians, too, who are ambitious that their country shall possess a Navy; such a thing could not have been dreamt of in 1913, but, in 1915, whisperings concerning Belgian aspirations on the deep Blue could be heard. It is said that there is a large body of opinion in favour of the creation of a Belgian Navy.

INFORMATION.

Switzerland.—A short article appears under the head of "The Soldier's Duty." The *Nouvelle Société Helvétique* has been interesting itself in military matters. A discussion, having taken place recently on the education of the soldier, a contributor to the *Revue* has prepared an epitome of "the soldier's duty," which according to him consists of:—

(1) *Pride* of uniform; (2) *Loyalty* to the flag; (3) A proper sense of *duty;* (4) *Energy* in carrying out duties; (5) *Courage;* (6) *Respect* for constituted authority; (7) *Comradeship;* (8) *Truthfulness* and nobleness of character; (9) *Discipline;* (10) *Vigilance.*

The *law of self-sacrifice* is, and must remain, the paramount consideration by which the soldier should regulate his daily life.

The number of the *Revue* concludes with a *Bulletin Bibliographique;* it contains, *inter alia,* brief notices relating to a number of works dealing with the Great War.

A further part of M. Epuy's translation of Lord E. Hamilton's work, *The First Seven English Divisions,* accompanies the April number of the *Revue.* The story is brought down in this part of the translation to the events which took place in the neighbourhood of Messines and Wytschaet towards the end of October and the early days of November, 1914.

No. 5.—*May,* 1918.

THE FUTURE OF THE CAVALRY IN SWITZERLAND.

The author of the original article deals with the question of the *rôle* of cavalry in modern war from the point of view of the experience gained during the great conflict now in progress. He is of opinion that, from the lessons learnt so far, no very revolutionary changes in cavalry tactics or in the technique of the cavalry combat would appear to be necessary under present-day conditions of fighting. Modern armies will continue, he says, to have need for a certain proportion of cavalry in the

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future; and cavalry will still remain the eyes and ears of the Higher Command; still act as a screen in front of an army prior to the actual collision; still form the strategic reserve required for the purpose of delivering the knock-out blow in the battle; still cover the exposed flank or flanks of an army; still be the saviour of an army in retreat; still transform a retreat into a rout; as much as is herein stated was accomplished by the cavalry in 1914. On the other hand, it is recognized that a strategic reconnaissance by cavalry is a thing of the past; further, this arm can no longer hope to penetrate the dense screen which nowadays covers an army during the period of its mobilization. The air service must henceforward undertake these duties and others of a similar nature that cavalry can no longer effectively perform.

The extent to which cavalry can be usefully employed as a screen to an advancing army, or one halted, will necessarily depend on the plans of the Higher Command and the character of the fighting about to take place. The Germans in the present War have discouraged the employment of their mounted troops for bringing about purely cavalry encounters. The German cavalry has, as a rule, followed the infantry, and, at times, the advanced infantry detachments. On the other hand, the French cavalry, at the beginning of the War, acted on its old traditional lines, and it reaped the harvest of its mistakes. The raid of Sordet's Cavalry into Belgium was a useless and wasteful jaunt; on reaching Liège, Sordet found the town invested by the Germans and was compelled to return without having been able to do anything effective.

The instructions issued to the French cavalry in September, 1914, by Joffre, brought the hazardous enterprises being undertaken by this arm to an end. The French cavalry, in consequence, proceeded forthwith to adapt itself, as best it could, to the requirements of the day; for more than three years now, it has been largely employed as infantry. On the Western front, the German cavalry has also had to a very great extent to act as infantry, but in Galicia, Poland, Russia and Roumania it has often been able to play the part for which it has been raised, trained, and equipped. The opinion is expressed that had it been possible for the Central Powers to employ a cavalry corps in Italy in the Autumn of 1917 the discomfiture of the Italians would have been complete; fortunately, the solid wall of the Alps caused the latter to be spared this supreme distress.

The case for the continued existence of cavalry is, in the opinion of the author of the original article, "proved in," as our American cousins would say. However, it is only after the infantry fight, and particularly in a retreat, that cavalry can nowadays usefully intervene.

Its great mobility enables cavalry to act wide of a flank and to cover it, and cavalry can also be employed for the purposes of momentarily filling up a gap in a front, one which cannot be closed by any other means. But, in order that it may successfully undertake such duties, cavalry should be armed accordingly and also be provided with the technical equipment necessary to enable it to act on the offensive or the defensive according to the requirements of the moment.

Cavalry is an expensive arm, one particularly vulnerable and difficult to handle. The principal advantage cavalry possessed over other arms

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formerly was the greater speed with which it could move from one point to another ; in view of the great developments in mechanical transport that have taken place in recent times, this superiority in speed is, to-day, largely discounted ;. infantry can nowadays be carried almost as quickly from one locality to another as cavalry would take to move across the space intervening between these localities.

Although it can no longer be said that the use of cavalry is absolutely indispensable in a modern battle, yet it remains true that its employment in attack may on certain occasions still prove invaluable, in others absolutely necessary. The opinion is expressed that, at the beginning of the War, it would have proved advantageous to the French if, instead of having ten cavalry divisions, they had had fewer such divisions, but more machine guns and more heavy artillery. On the other hand, in view of the heavy losses in horses suffered by the Germans, their cavalry force has not been too large for the tasks imposed upon the German Army.

Turning to the question of the Swiss cavalry, the author of the original article states that, although cavalry nominally existed in Switzerland before the days of General Wille, it was he who has made the Swiss cavalry what it is to-day. General Wille was the first Swiss officer to recognize the possibility of turning militiamen into good useful soldiers.

In spite of all vicissitudes the cavalry arm still possesses to-day a peculiar fascination, and the cavalryman continues to exhibit the old spirit of dash with which this arm has always been associated ; nowhere more so than in the case of the Swiss cavalry.

The author of the original article has no hesitation in saying that the retention of the whole of the divisional cavalry of the Swiss Army—the Guides—is necessary. However, he has some doubt as to the strategic value of the remainder of the Swiss cavalry—the so-called *cavalerie de combat*—consisting of 24 squadrons of Dragoons with 32 machine guns. The great development of machine-guns, the introduction of Q.F. guns into the artillery, the flattening of the trajectory of the projectile fired from the infantry weapon, the enormous growth in the mechanical transport with an army, the progress made in the aviation services all seem to point to the same conclusion ; namely, that the Swiss cavalry, unprovided as it is with horse artillery, would not have the ghost of a chance should it come into collision with the cavalry of the Powers which are Switzerland's neighbours.

It is urged that the pompous title of " brigade," which is given to the formation consisting of six squadrons, with their eight machine guns, should be dropped in the Swiss cavalry and that the use of the term regiment substituted therefor ; further that the present regiment should be styled " group." But, since Switzerland cannot hope to compete in armaments with her neighbours, it would be preferable, in the opinion of the author of the original article, to abolish the Swiss cavalry as *cavalerie de combat* altogether.

Now that machine-guns have been allotted to infantry battalions, the mounted machine-gun groups in the Swiss Army have, it is thought, practically lost their *raison d'être*. It is urged therefore that a more suitable use could be made of Swiss resources by a reorganization of the

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cavalry and the mounted machine-gun groups, and by forming out of them a division of a type hitherto unknown in the Swiss Army. Such a division should, it is suggested, consist of a cavalry brigade of two regiments, each of six squadrons of Dragoons and three of mounted machine-gunners. This division would thus absorb 12 squadrons of the Swiss cavalry, six of the groups of mounted machine-gunners at present with the divisions and also the group of machine-gunners with the Landwehr cavalry. The remaining 12 squadrons and two machine-gun units should, it is recommended, be distributed between the six groups of divisional cavalry.

The foregoing reorganization would still leave over a certain number of horses now with the 12 squadrons which, it is recommended, should be split up among the divisional cavalry; these animals, it is suggested, could be utilized in connection with the raising of two new batteries of 15-cm. howitzers. These howitzers should, it is recommended, be hauled by mechanical transport on the roads; the horses being available to bring the pieces into action when necessary to move them off the roads.

THE PRESS IN BELGIUM.

The original article is based on a very entertaining volume entitled *La Presse clandestine dans la Belgique occupée* by M. Jean Massart. We have all been made familiar with the skill and ingenuity displayed by enterprising Belgian patriots who not only published the paper styled *La Libre Belgique* after the German occupation of the Belgian capital, but also managed regularly to furnish a copy thereof to General von Bissing, the Governor of the invaded territories, at his offices. Greatly daring the Editor of this publication contrived at and succeeded in photographing von Bissing in his office, whilst he was in the act of perusing the latest number of the *La Libre Belgique* delivered for his use. This photograph was reproduced in the publication under the title "His Excellency Governor von Bissing with his intimate friend" and under it appeared the explanatory legend: "Our beloved Governor, sickened at the lies in the censored Press, seeks for truth in *La Libre Belgique*." Von Bissing was duly favoured with a copy of the number in which this photograph appeared. In spite of all the measures adopted by the German authorities to track down the publishers of the paper in question and the precautions taken to suppress it, the Editor was able to defeat German vigilance, so that the representatives of Might found themselves defeated by the defenders of Right.

Before the Germans marched into Brussels the majority of the owners of the printing presses had rendered them useless, whilst the remainder refused to submit to the German censorship. During the first fortnight or so after the arrival of the Germans in the Belgian capital, it was still possible to obtain foreign newspapers in Brussels. The Germans then put a stricter guard on the Dutch frontier and it became extremely hazardous to smuggle papers into Belgium from Holland. About this time the publication of certain pseudo-Belgian papers was started in Brussels, but, being under German control, the news therein was thoroughly distrusted and to this fact is it due that the clandestine Press came into existence.

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The Germans, very early after their arrival in Brussels, took in hand the task of keeping the Belgian population informed concerning the course of events connected with the War (naturally from their own point of view). Four methods were employed by them; they distributed leaflets free of charge and put up posters; they caused to be offered for sale printed notices; they allowed certain Dutch papers to be sold in Belgium; and they caused a certain number of pseudo-Belgian dailies to be published.

1. *Distribution of Information (Without Charge).*—The information supplied gratuitously was contained, at first, almost exclusively in posters, and related to the military operations. It was untruthful in many particulars; for example, in one of these posters an allusion was made to the first Battle of the Marne and in the very brief reference thereto it was stated that the rumours current alleging a want of success on the part of the German arms were false.

Feeling that the posters alone would not attain the object in view, pamphlets printed in German, French and Flemish were also distributed broadcast free of charge; these pamphlets dealt, *inter alia*, with such matters as the Anglo-Belgian Conventions, the Chancellor's speeches, etc. Further, an immense amount of propaganda literature was poured into Belgium from the region E. of the Rhine; therein the violation of Belgian territory, the sack of Louvain, etc., were written up from the German standpoint. Finally, Belgians, having family or commercial relations with persons resident in the Fatherland, were inundated with letters, in which they were told that Germany was sure to be victorious and that Belgium would be annexed, etc.

2. *German Printed Matter in Belgium.*—German printed matter reaching Belgium consisted of newspapers, pamphlets and picture postcards. The Belgians never believed what they read in German newspapers; and an incident confirmed their suspicions. It was one day discovered that the issues of the *Dusseldorfer General Anzeiger* were published from two points of view; one containing news for consumption on the Western Front and another that for consumption on the Eastern Front. Owing to missortation copies intended for Russia reached Belgium, and the Belgian public saw on the front page of one version the announcement of "A new German advance in the Argonnes," whilst in the other version they observed an announcement, in the same position of the front page, that the Russians were ripe for peace.

It was intended that the Belgian public should believe that the pamphlets referred to were the handiwork of compatriots loyal to their country; they were not to be thus deceived; for it was at once recognized that the contents thereof were the production of German brains.

The picture postcards absolutely failed in their object and, indeed, made the Germans appear ridiculous in Belgian eyes; in some of them Uhlans were depicted guarding the Eiffel Tower, in others Germans were shown carrying the ramparts of Liège (an open town) by assault, civilians were represented firing on Germans in the streets of Louvain, etc.

3. *Dutch Newspapers.*—Only Dutch papers of Germanophil tendencies, such as the *Nieuwe Rotterdamsche Courant*, were permitted free circulation.

4. *Pseudo-Belgian Newspapers.*—A fortnight after the arrival of the

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Germans the first pseudo-Belgian newspaper put in an appearance. At first, no news from the Entente territories was permitted to be published, but later a concession was made to the public on this point. However, these newspapers very quickly fell into discredit.

It was the strictness of the German censorship and the persistent effort to misrepresent the actual state of affairs that gave birth to the clandestine Press in Belgium. Books and papers were smuggled into Belgium; they were recopied, reprinted and distributed to the public in secret and German vigilance was completely defeated.

(*a*). *Importation and Reprinting of Newspapers and Books.*—Almost simultaneously with the arrival of the German battalions in Brussels, *en route* for Paris, a few bold patriots organized a service for the importation of home and foreign newspapers into the Belgian capital. Thus the residents in Brussels were able to read *Le Matin* and *La Métropole* (of Antwerp); *La Flandre libérale* and *Le Bien public* (of Ghent) which were smuggled into the city in vegetable hampers and sold secretly by hawkers of fruit, etc., at 65 centimes apiece. Among the foreign papers purchaseable were *Le Journal, Le Petit Parisien, Le Matin, Le Temps*, the English *Times* and *The Daily Mail*; the Dutch *De Telegraaf*; the Swiss *Le Journal de Genève.*

The difficulties of getting these papers into Belgium became so great that the price of the *Times* rose to 5 francs a copy, and, it is stated, that as much as 200 francs has been paid for a single copy of this paper.

Soon German agents (in disguise) were sent out to sell the prohibited papers in the streets of Brussels. This gave rise, on one occasion, to a collision between one of these German agents and a Belgian hawker who resisted arrest by the agent. Two Belgian policemen thinking that their countryman was being unlawfully attacked, and not realizing that he was engaged in trafficking in smuggled goods, went to his assistance. The upshot of this encounter was that a fine of five million francs was imposed on Brussels.

Books such as *Les Crimes allemandes*, by Bédier; *La Violation de la neutralité belge et luxembourgeoise par l'Allemagne*, by Weiss; *J'accuse*; *La Belgique neutre et loyale*, by Waxweiler, were also smuggled into Belgium. Naturally, the circulation of these books was very limited, and those who trafficked in or had them in their possession ran great risks. The rarer publications were manifolded by photography and by the typewriter. Leaflets were also circulated daily or periodically; some of them were devoted to military events whilst others contained extracts from the Entente Press. Further, even Raemacker's drawings were reproduced and circulated in *La Cravache.* The thirst for information brought many into trouble and they were sentenced to long terms of imprisonment; a punishment which was borne, as a rule, with cheerfulness. The Germans were able to muzzle an individual here and another there, but they have not succeeded in putting an end to wide-spread propaganda.

(*b*). *Original Publications.*—The most interesting and most extensive productions of the Belgian Press have consisted of original contributions from Belgians who have remained in the occupied territories and have suffered all manner of vexations and persecution at the hands of the

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invader. Among the papers printed and published during the German occupation of Brussels *La Libre Belgique* easily takes first place for audacity. This bulletin, published at " regularly irregular " intervals (as stated on the title page) would, it was notified, be sold at a price per copy which was " elastic from zero to infinity (vendors requested not to go outside these limits) " ; the telegraphic address of the paper was given at the " Kommandantur, Bruxelles " ; and its offices, " not being a place of complete repose, were located in an automobile cellar." The publishers announced that they did not accept advertisements, since " business is at a complete standstill under German rule ; the advertisement columns have, in consequence, been suppressed and customers are advised to save their money for use in more propitious times." There was a complete mystery concerning the identity of those responsible for the publication of this paper ; some suggested that it was being run by Jesuits, whilst others gave the credit to Freemasons.

Many a hoax was played on the military authorities by putting them on a false scent. On one occasion a patrol was, in consequence of a communication received on a certain subject, sent to the André Vésale Statue, in the Place des Barricades, and the number of *La Libre Belgique* issued directly afterwards facetiously published a drawing representing the arrest of the Statue in question. Other incidents of a similar nature are referred to in the original article.

La Libre Belgique was not the only prohibited paper in circulation in Belgium, *La Verité, Le Belge, Patrie* kept it company, as also *De Vlaamsche New* which announced that its editorial offices were located at the " Kommandantur, opposite to the printing press of *La Libre Belgique*." *De Vlaamsche New* was entirely devoted to satire ; it was nearly run to earth and therefore ceased publication. Every copy of *La Libre Belgique* was, on an average, read by at least ten individuals, and the Editor of this paper was as defiant towards the military authorities in Brussels as John Wilkes proved to be towards the British Government of his day in connection with the authorship of the well-known *North Briton*.

After three years and more of their occupation of Belgium, the Germans find that the Belgians are untamed and untameable. To this day, they are being lampooned, in the clandestine Press of Belgium, in relation to their Goth-like cruelty, which has stimulated Belgian resistance instead of crushing it out. The measures adopted by the German authorities in Belgium have had the effect of turning practically the whole civilized world against them and has won for them the " holy hatred " of the Belgian nation.

A Durable and Immediate Peace.

Colonel Feyler informs us, in the original article on the above subject, that a Swedish author, M. Ragnar Paijkull Sturzenbecker, has sent him a pamphlet entitled *Droit au but. Les conditions essentielles pour une paix durable* in which the peace problem is discussed. The author of the pamphlet starts with the proposition that a moral reform is first necessary before peace can be secured on a permanent basis. He is of opinion that every one, the peoples of every country as well as the Governments thereof, must renounce their vanity, their unleavened

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Imperialism, as a first step. To this end the distinction between the "Great Powers" and the "States of secondary importance" must be abolished. The rights of all Powers, he urges, should be co-equal irrespective of their territorial extent. They should also all obtain free access to the sea; this can be secured, he points out, by the internationalization of all the means of communication, the railways, the rivers and the free space above land and water. M. Sturzenbecker proposes further to internationalize the navies and armies of the world, and to transform them into an international police for the purpose of preventing acts of violence between nations and in order to maintain the *statu quo*. Finally, his scheme is completed by the proposal to establish an International Parliament, wherein each State shall be represented by a similar number of members; this Parliament to be assisted by an International Bureau created for the purpose of providing advice and exercising Executive Powers.

The foregoing proposals are really not any more illogical than those which have already been put forward for the formation of a League of Nations, nor do they bring us any nearer to Utopia.

M. Sturzenbecker seems to think that the acceptance, in principle, of his proposals by the world at large must lead to an immediate peace. Colonel Feyler expresses the opinion that a perusal of the pamphlet in question creates the impression that in spite of the author's evident effort to steer a straight course, his bark yaws dangerously between Charybdis and Scylla, and in trying to shun one of these rocks it runs into the other; in consequence, M. Sturzenbecker does not appear to advantage as a navigator in turbulent waters. Moreover, his propositions are based on the postulate that "objectivity" is not concerned with the question as to whose is the responsibility for starting the War. What matters, he says, who began the War; it exists and the whole world wishes to see the end of it. Three matters alone, according to him, require to be cleared up in connection therewith, namely;—

For what reason or reasons have the several nations participating in the War entered into it?

What are the present aims of each of them?

On what conditions would each of them negotiate a peace at the present time?

The author of the pamphlet claims to have discovered the replies to these questions in the speeches of the Statesmen of the several belligerent countries and in the proclamations issued therein. The replies to the three questions are, in his opinion, identical in each case.

As regards the first question, *they all* say that they are at war because *they were attacked; they all* claim that their adversary has had recourse to arms owing to rivalries on land and on water; *they all* add that they are at war *against their wish.*

As to the second question, *all* the belligerents affirm that their object is to win victory for the sake of humanity and in order to secure a durable peace which may guarantee free development to the nations of the world.

As to the third question, *they all* demand that *all territory conquered* shall be restored and an indemnity paid for *all damage done.*

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Thus the whole world is, according to M. Sturzenbecker, saying the same thing and he argues that therefore the whole world is in agreement on the subject of the War and the desire to bring it to a conclusion. An understanding can be arrived at, he thinks, by the restoration of conquered territory and by payment of indemnities for the damage done; he proceeds to show how a settlement can be arrived at according to his conception of the situation. He places the belligerent countries in three categories:—

Belgium and Greece are, he says, incontestably entitled to have their full sovereign rights restored to them and to the payment of indemnities for the damage done; they were in no way responsible for the War.

Italy, Roumania and Montenegro entered the fray of their own free will and, therefore, the question as to how these countries should be dealt with must depend, says M. Sturzenbecker, on whether the doctrine that war produces definite results and each side must consequently accept its gains and losses is to govern the situation or, on the other hand, on whether the doctrine that neither the aggressor nor the party attacked, neither the victor nor the vanquished have positive rights is to prevail.

France, Russia and Serbia have, according to the author of the pamphlet, every right to claim back their occupied territories. Germany and Austria have no right to keep the property of others seized by them under the pretext of war.

Similarly, he argues that Germany is entitled to have restored to her the German Colonies seized by the British, since it was Great Britain that attacked Germany, although he admits that she was *forced* to do so under "the circumstances."

Colonel Feyler states that he does not know whether M. Sturzenbecker's arguments are to be taken objectively or subjectively; in any case, he does not accept the logic of the latter's reasoning. It was not, says Colonel Feyler, "the circumstances" that compelled Great Britain to declare war against Germany, but "a circumstance" voluntarily created by Germany, one which she was free to create or not as she desired. In invading Belgium, Germany was guilty of committing a felony, and it was the commission of this crime that brought Great Britain on the scene to deal with the malefactor. For this reason, Germany must be mulct in the costs of the trial. M. Sturzenbecker draws no distinction between acts which comply with the highest standard of probity and those that are tainted with the deepest iniquity.

M. Sturzenbecker considers that *it is the modern military system universally adopted by all nations that is responsible for the present conflict*, and that the European States have been led into the War by a demon, whose predominating *idea is that all disputes must be settled by acts of violence*.

This method of reasoning naturally implies that the author of the pamphlet is of opinion that all the belligerents are alike guilty and have all been inspired by the same demon. Colonel Feyler does not accept this sweeping assertion. He points out that whilst certain individuals certainly acted on the promptings of the demon, yet there were others who not only resisted the tempter but also endeavoured to prevent the others from being led astray. It is important to keep the individuals

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in question in two different classes, according to the attitude shown by them at the outset.

M. Sturzenbecker has made a fundamental error in ascribing the same value to the utterances of the spokesmen of the various belligerents. He shuts his eyes to the fact that Wilhelm II. presided at the Council held on the 29th July, 1914, at which the War was decided upon; he appears to attach no importance to the fact that Wilhelm II. suppressed the telegram sent him by the Ex-Czar appealing for a submission of the matters in dispute to an Arbitral Tribunal to be appointed under the provisions of The Hague Conventions; he ignores the fact that the reasons given by the Kaiser in declaring war against France were a tissue of lies.

With what confidence can the belligerents, in view of past experiences, accept the declarations of the Central Powers regarding their respect for the independence of other nations? The negotiation of a peace on the basis of "no indemnities and no annexations"? No one is likely willingly to allow himself to be made a dupe as have been the Bolsheviks.

If a moral reform of humanity is a condition precedent to the establishment of a durable peace, then in order there may be immediate peace, as a further condition precedent, it is also necessary that by some means confidence should be restored in the good faith of the Central Powers, in order that their word may be believed; at the present time three-quarters of the civilized world places no reliance on any promise that may be made by these Powers. Even the propaganda of the Central Powers in neutral countries is so glaringly untruthful as to make it stink in the nostrils of all honest and impartial men.

Colonel Feyler thinks M. Sturzenbecker makes a great mistake in considering the present struggle as being a simple conflict between nationalities, identical in all respects with those which have taken place in ages past. The present struggle, on the contrary, is something vastly different, it is a conflict between two ideals of civilization; on the one side, that of the civilization of liberty and of one affecting the dignity of the human race, and, on the other, that which the Germans have themselves baptized the "civilization of organization." It is impossible to reconcile these two ideals; liberty and subjection are ideas very wide apart. Which of these ideals shall prevail must now be decided on the battlefields of Western Europe. Neither the homilies of neutrals nor those of pacifists can procure a judgment of binding force on this question.

Humanity is, at the present day, divided into three camps; the belligerents whose cult is subjection; the belligerents whose creed is liberty; and neutrals, who, by the very fact of their neutrality, admit that their fate must be sealed by the belligerents. If success falls to the former of the belligerents, neutrals see vassalage staring them in the face; on the other hand, if victory is secured by the latter of the belligerents, neutrals can breathe freely, for an era of progress and development is assured them.

M. Sturzenbecker's sincerity is not questioned, but he has, says Colonel Feyler, made the mistake of not treating acts done in bad faith as being in a different category to acts done in good faith.

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Notes and News.

Switzerland.—The Swiss who are fighting in the Foreign Legion on the Western Front come in for a word of praise. They have, says the writer of the original article, the good fortune not to be "neutral" and, having fought against an enterprise whose aim is domination, they have been fighting for their country.

Attention is called to a work entitled *Articles et discours* by Colonel E. Secretan; the contents thereof deal with the period 1st August, 1914, to 1st August, 1917. Colonel Secretan has been a staunch champion of Swiss neutrality. The volume in question contains matter of two kinds; one kind relates to the events of the Great War, its strategy, the spirit of the conflict, the armies and peoples of the belligerent States; the other deals with the situation of Switzerland whilst surrounded by nations at war, the internal troubles of the Republic, and the mistakes made by its Government. There is much food for reflection in Colonel Secretan's work.

Another work claiming attention is *Le témoignage d'un citoyen* (sub-title *Études de politique Suisse*) by Albert Bonnard, who was at one time a collaborator of Colonel Secretan. This work has been compiled by M. Louis Debarge, Director of the *Semaine littéraire*, who has collected therein articles contributed, before and since the War, by Bonnard to the *Foyer romand*, the *Semaine littéraire* and the *Bibliothèque universelle* and other publications. The Swiss Army and its affairs occupy a prominent place in this collection of articles; as also do the opportunism and arbitrary conduct of those who have been responsible in recent years for directing the policy of Switzerland.

M. Henri Naef has written a pamphlet on *Antimilitarisme et défense nationale;* therein he expresses the opinion that the first duty of every honest man is to go to the succour of a neighbour who may be unjustly attacked; further, that it is an unnatural thing for a man to commit suicide and equally so for a nation, which is but a collection of individuals, to do so. A people that ceases to defend itself, he points out, disappears in time from the face of the earth and, in doing so, does not contribute to the advancement of the interests of humanity.

Information.

Switzerland.—Shorthand, it is said, has been somewhat neglected in the Swiss Army. Much time is lost at the present time by taking down minutes in long hand and in transmitting orders over the telephone. A necessity for a more wide-spread knowledge of shorthand is urged by the writer of the original article.

This number of the *Revue* concludes with a *Bulletin Bibliographique.*

The final part of M. Epuy's translation of Lord E. Hamilton's *The First Seven English Divisions* accompanies the May number of the *Revue.*

W. A. J. O'Meara.

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RIVISTA DI ARTIGLIERIA E GENIO.

JULIUS CÆSAR AND THE WAR OF POSITIONS IN THE SPANISH MARSEILLES CAMPAIGN, 49.

Marseilles, the most important commercial town in the western basin of the Mediterranean, was at the period under notice a land and maritime fortress of the first order. Surrounded on three sides by the sea, it was closed on the fourth by a strongly fortified girdle the value of which was increased by more numerous and powerful engines of war possessed by any other fortified places of that epoch.

The principal factor of the defence, however, was the fleet. Marseilles had an important maritime arsenal and a port defended by powerful fortified works which offered to the fleet a secure base both for the offensive and the defensive. When Domizio Enobarbo assumed the command of the city, his first care was to reinforce the fleet. After the experience of the preceding campaign in Italy, he had reason to suppose that Cæsar had met with difficulties in procuring ships, and that on the sea there was the possibility of obtaining a victory. All the war ships were sent into the neighbourhood charged to requisition as many boats or ships of any kind that they might find, transforming them for war purposes, and demolishing some, using the material for the repairs and adaptations. Cæsar, as it was known had arranged for the equipment of 12 war ships in Arelate and had entrusted the command to Decio Brutus. The attack on the land side was to be conducted by Trebonio with his three Gallic legions.

When he arrived Trebonio made his preparations for the siege. After having enrolled a great number of workmen, he transported to the town a large quantity of material, and commenced the operations for a regular siege by the construction of two colossal terraces.

Owing to the depression of the ground in front of the walls, these terraces had to be made with an average height of 80 ft., and their construction required an enormous movement of earth and the use of great quantities of material. On the other hand the great powers of the Marseilles machines, both as regards their range, and the penetration of their projectiles compelled the assailants to commence their works at a certain distance from the walls and to adopt those of greater dimensions than those commonly in use. This was the cause of the slowness of the attack and necessarily it delayed the decision for the attack on the land side. A resolute action had then first to be made from the sea.

The ships ordered by Cæsar were ready in a month—towards the end of May—and then selected troops drawn from the legions were embarked, they were abundantly equipped with grappling hooks, landing platforms, and light machines.

The marine element, properly so called, consisted of crews taken from the merchant ships leaving as many as might be necessary. Brutus occupied the small group of islands opposite the port and awaited the enemy's fleet which consisted of 17 great war ships, and a great number of smaller ships manned by mercenary troops, but with selected sailors considerably better than those of Cæsar's fleet.

On the 27th June the Marseilles fleet under the command of Domizio

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Enobarbo sailed out of that port. Brutus had drawn up his ships in front of the group of islands selected by him for his naval station. The Marseilles ships were extended on an ample front, attempting to turn the Cæsarian fleet and manœuvring in a manner that several might attack each of the enemy's ships simultaneously and damage their oars. Owing to this manœuvre the Cæsarians found themselves at a great disadvantage, but they did not try to avoid the enemy's attacks, and even made their ships to approach nearer in order to bring into action their grappling hooks, and to bring on hand-to-hand combats in which Cæsar's veterans excelled.

Several of the Cæsarian ships succeeded in capturing two of the enemy's ships. In this manner after the Marseillaise had lost nine ships they had to abandon the combat and to retire to the harbour closely pursued. It was this naval combat the notice of which going to Ilerda had produced so great an impression.

The Marseilles fleet although beaten was not destroyed and with the powerful resources that it had at its command was able to return to the attack. Fresh ships were brought out, a great number of fishing vessels adopted for war purposes and armed with light engines, and on these were embarked detachments of archers.

In the meantime unexpected assistance had arrived at Marseilles. Pompey had sent from Greece 16 ships under the command of the legate Nasidio. These had succeeded in surprising the Cæsarian fleet which was found in the straits of Messina and had forced a passage; one ship was captured, a swift sailing ship was at once sent to Marseilles to announce the speedy arrival of reinforcements. Nasidio with his 16 ships anchored near Taurenzio, a coast fortress situated about 30 km. from the city. The Marseillaise did not allow the occasion to escape them for taking a reprisal. With all their fleet they left the port, and undisturbed joined Masidio near Taurenzio. The two fleets reunited advanced in line against the Cæsarian naval station, the Marseillaise on the right and Nasidio on the left. In the meantime Brutus had reinforced his fleet with ships captured from the enemy in the last combat, profiting by the time gained to drill his sailors.

On receiving notice of the reunion of the two enemy's fleets he set sail with his ships to meet them. The battle took place half-way between Marseilles and Taurenzio. As soon as each ship had the necessary freedom for manœuvre Brutus tried to extend his line as far as possible, endeavouring at the same time to provoke the enemy's attack. But they had become prudent; each time that one of their units came to board the Cæsarians, some ships that were in reserve at once hastened to give assistance and compelled the enemy's isolated ships to retire.

The combat was protracted in this manner without either of the contending ships being able to obtain a victory. Two of the Marseillaise ships attempted then simultaneously from two sides to ram the ship of Admiral Brutus; but he at the last moment succeeded in avoiding the shock, sailing rapidly ahead so that the two enemy's ships came violently into collision, each being so much damaged that they remained helpless for defence. Several of Cæsar's vessels closed in at once on the two Marseillaise ships which were sunk.

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Brutus hastened to penetrate into the gap produced in the enemy's lines, and succeeded in separating the left wing commanded by Nasidio and compelling them to take to the high sea. The mass of the Marseillaise, isolated and weary after their losses, took refuge in the port. Five of their ships were sunk, four were captured, one which remained isolated succeeded in escaping towards Spain together with the detachment of Nasidio which had not undergone other losses. The Marseillaise fleet was now out of action, and the strong maritime city found itself blockaded from the sea front.

By force of circumstances, the operations proceeded more slowly on the land side. Notwithstanding the great quantity of material that Trebonio had collected at the commencement of the works it is related that the normal types of the works for attack were not sufficient. Not only the powerful engines of the besiegers were effective at a great distance, but the penetrating force of their projectiles was such, that the means of cover used up to then did not offer the necessary resistance. Against the long beams pointed with iron, there were thrown gigantic balls from a great distance, the defences consisting of wooden beams and entanglements. This being the state of things, it became necessary to construct in front of each of the two terraces a strong parapet, under the protection of which they proceeded to the construction of terraces in the usual manner, levelling the ground step by step, but with a structure more solid than that adopted in other sieges.

The nearer the besiegers approached the walls, the greater became the confusion. Heavy projectiles and incendiary materials were thrown in great quantities, and the besieged becoming fatigued had to seek protection from the losses caused by the projectiles, and suffocated by the burning pitch, but they also had to repel the attacks always more frequent and violent as the distance diminished. To oppose a more effective resistance, especially to the sorties, the troops occupied in the construction of the terraces on the right endeavoured to create a *point d'appui* outside these terraces. They built up a tower of bricks of four stories 10 m. in width, with great beams (1.60 m.), covered with a roof formed of beams and planks. When they found that the towers offered the necessary protection they decided to raise them and in an ingenuous manner effected the elevation of the roofs. On these a screen was fixed consisting of rope netting hanging downwards. The whole mass of the roof and screen was raised by windlasses and then followed the construction of the walls of the new story. The tower in this manner reached to a height of six stories, so as to dominate the city walls ; the upper story was provided with loopholes from which by means of engines placed in the interior they were able to successfully resist the crowning of the walls. The work originally erected with a defensive scope became finally a most efficacious means of attack.

Owing to difficulties of the ground, the construction of the terraces proceeded very slowly, the legionaries, always protected by their towers, constructed a strong movable musculus, 20 m. in length, made of planks covered with bricks as a protection against incendiary projectiles. The musculus pushed forwards on rollers was suddenly thrust from one of the towers of the wall, and from this they commenced the work of demolition.

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The besiegers saw the danger, and overturned the walls, using at the same time burning pitch, also damaging the musculus. Finally one part of the mural tower collapsed and the remaining part had to be evacuated by the defenders; the breach was open.

It was the 10th of October and the Marseillaise thought that the city could not hold out any longer; and considering the exasperation of the Cæsarians believed it better to capitulate than to await the enemy's attack. An armistice was then decided upon until the arrival of Cæsar and then they made an unconditional surrender. Trebonio had received from Cæsar a formal order to prevent the sacking of the city, the result was good; he accepted the demands and made a cessation of hostilities.

December, 1917.

AUSTRIA-HUNGARY.

Dismounted Cavalry.—Distribution of Mitrailleuses.—From notices collected from *La France Militaire* it appears that portions of the cavalry divisions, especially the 5th, 6th, 10th, and 11th, are dismounted. The regiments have a new organization with reinforced effectives, and a larger allotment of mitrailleuses. Each of these regiments are composed of two half regiments with three squadrons armed with rifles and one squadron of mitrailleuses. To every half-regiment there will be added a 4th squadron of rifles whilst up to the present time there has only been one for each division.

The squadrons of mitrailleuses have four sections each with two mitrailleuses. But according to an order of 19th July, 1917, issued to the 7th Army, all the dismounted squadrons have a section of four light mitrailleuses with the infantry companies. So that the regiment has altogether 48 mitrailleuses.

BELGIUM.

A New Type of Mortar.—One of the sectors at the front where mortars are largely used, is that occupied by the Belgian Army. This new arm has been minutely studied in that army. *La Revue Militaire Suisse*, in an article on *artillerie de tranches*, gives some data on the new perfected mortar in use in the Belgian Army.

Its principal value seems to be the great exactness of its fire combined with lightness of material and facility of service. Four men are sufficient for the transport and service of the mortar; it can discharge two kinds of projectiles of weights respectively of 36 and of 19 kg. with rapid fire. The fire once regulated there are no displacements which have to be regulated in the installation of the mortar. The deviation in the range does not exceed 3 m. in 1 km. of distance. The construction of the new mortar is also very simple and the cost is small.

GERMANY.

War Organization for Pioneers.—At the commencement of the War to each army corps, active or reserve, there was assigned a battalion of pioneers of three companies. Other formations of this service were destined for the attack and defence of fortresses.

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According to information in *La France Militaire* in the course of the campaigns the number of units of pioneers has been much increased by companies created from existing regiments and battalions, and also by independent companies. In the great units, the companies are assigned not often to the army corps but directly to the divisions; in addition to those with the army corps there are reserve companies of pioneers which are assigned to different sectors according to requirements.

At the commencement of the current year the organization was stated to be complete, giving to each division two companies of pioneers. Other formations, not comprised in the organization for divisions are at the disposal of the great general staff and the commands of armies, and comprise regiments of fortress pioneers and companies of miners, besides the special battalions destined for the service of flame throwers and asphyxiating gas.

Perforating Bullets for Rifles.—The introduction into the service of shields for field artillery has caused trials to be made in order to obtain perforation of the shields by small bullets of special make for rifles fired at a moderate distance.

An article published in the *Genie Civil* that to the German selected marksmen there are distributed cartridges with small perforating bullets which are distinguished from others by having an internal nucleus of steel with tungsten.

JAPAN.

New Rifle.—The Japanese Colonel Kijiro Nambu—as reported in an extract from the *Corriere di Haifong* published in *La France Militaire*—had invented a new rifle, which is stated superior to the rifle now in use, by its range, its simplicity, the strength of its mechanism, and its lightness and rapidity of fire. The calibre is stated to be increased. Mention is not made of its being an automatic rifle.

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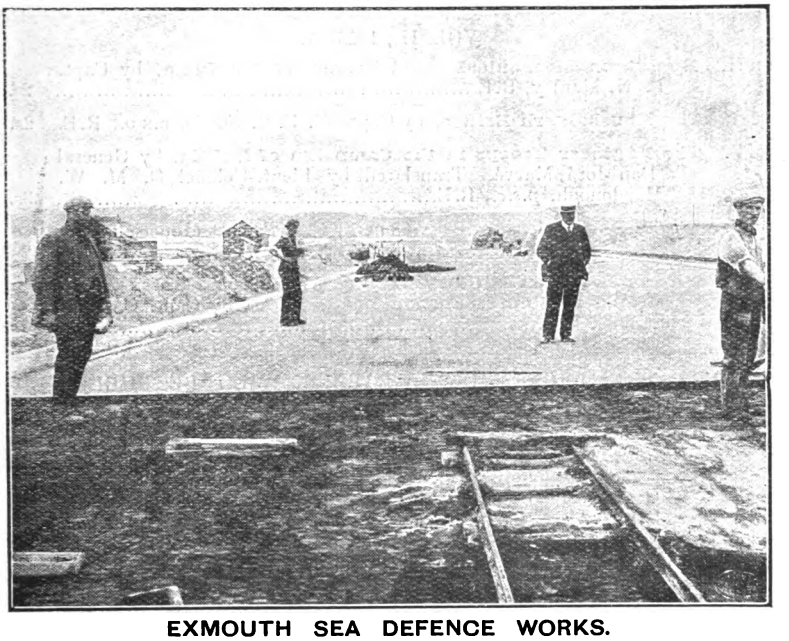

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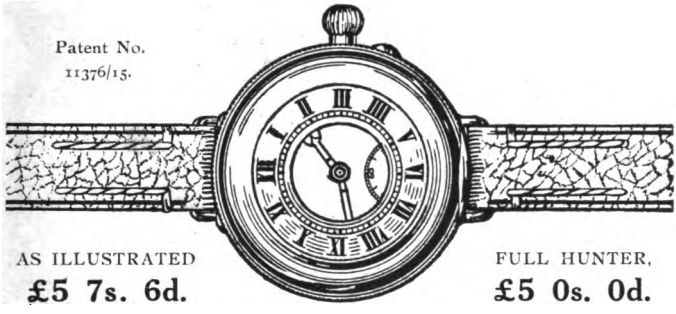

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LECTURE II.

CHLORATE EXPLOSIVE MIXTURES.

IN the first lecture I dealt with the various nitrate mixtures. Next in importance to these are the chlorate mixtures.

Potassium chlorate, $KClO_3$, is a non-deliquescent salt, which, on heating, gives off 39.1 per cent. of its weight of oxygen. It also gives out heat during the decomposition, 1 gram yielding 8.74 calories, and is, therefore, an explosive in itself. It is much used in the preparation of oxygen in laboratories, and if heated too rapidly may explode with great force, as many have found.

When mixed with combustibles it forms explosives much more powerful than nitrates mixtures, but also much more sensitive and dangerous to handle. The discoverer Berthollet, in 1788, tried to use it to replace saltpetre in gunpowder, but at the first attempt the mill promptly blew up and killed some of a company specially invited to see the process.

The sensitiveness may be illustrated by mixing a little powdered chlorate with sulphur ; it detonates sharply when struck on an anvil. Similarly with black antimony sulphide, and also with many other combustibles. Chlorate mixtures of this kind are now mostly used for purposes where sensitiveness is a necessity, as in percussion caps, friction igniters, etc.

The mixing of chlorate with combustibles of any kind in the dry state is always dangerous. When done, the substances should be ground separately in clean mortars, and mixed by sifting so as to avoid undue friction.

Potassium perchlorate, $KClO_4$, contains a greater percentage of oxygen, 46.2 per cent., but is a much more stable substance. Heat is absorbed in its decomposition, and mixtures containing it are less sensitive than plain chlorate mixtures.

Ammonium perchlorate, NH_4ClO_4, is still less sensitive, and is now much used in explosive mixtures. With plain combustibles it gives off hydrochloric acid gas when exploded, and as this is very objectionable with mining mixtures a proportion of sodium nitrate is added to convert the HCl into sodium chloride, NaCl, which is harmless.

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Potassium Chlorate and Sugar.—Many of the attempts which have been made to reduce the sensitiveness of chlorate mixtures have taken the form of using some imperfect combustible to mix with the chlorate, and sugar has often been proposed. A mixture of two parts of $KClO_3$ with one of sugar is as good as most. It is much less sensitive than a mixture of chlorate with carbon and sulphur, and has about twice the power of gunpowder. But it is still too sensitive and violent in its action. It can be exploded by contact with flame, by moderate percussion on an anvil, and also by contact with strong sulphuric acid. Use has been made of these properties in automatic igniters for other charges. It makes a good flare, but is not a military explosive.

Friction Composition.—Many variations are used, but the following gives the proportions of a typical mixture :—

Potassium chlorate	12
Antimony sulphide (black)	12
Sulphur	1

The substances are ground separately, mixed into a paste with spirit containing a little shellac, and formed into pellets, which are dried. Sometimes one part of ground glass is added to make it more sensitive. Sometimes gunpowder is added.

To show its properties apply a flame to a little ; it ignites instantly, and the flash is very efficient for igniting other explosives.

Put a little on an anvil and strike sharply. It detonates with moderate percussion.

Put a little on the anvil and rub hard with a hammer face ; it explodes sharply.

For many years this has been used in friction tubes for firing heavy guns, and is still used. The friction tube is a copper tube filled with gunpowder which is inserted into the breech of the gun. At the outer end is a cross tube, and in this is a kind of copper rasp or twisted wire. Pellets of the friction composition are pressed closely in contact with the " friction bar," so that when it is pulled out sharply by the gunner the composition explodes and ignites the gunpowder, which sends the flash that ignites the cartridge.

Igniters for safety fuze are made on the same principle. The fuze is tipped with a friction composition which, when rubbed with a prepared surface, flashes off and ignites the fuze.

Equal weights of amorphous phosphorus and chlorate make a most sensitive and powerful explosive formerly used in an Armstrong shell fuze. They are dangerous to mix dry, but can be mixed safely if moistened with methylated spirit, and then separated into very small portions. The mixture explodes with very gentle percussion or friction. It is used in toy caps.

The use of friction compositions is well illustrated by a box of safety

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matches. The match head is tipped with friction composition diluted with glue, and can be ignited by strong friction or by percussion. The box is coated with a little amorphous phosphorus and ground glass. A little friction between the two suffices to bring about ignition.

Flash Compositions.—A mixture of two parts of potassium chlorate and one part of magnesium or aluminium powder, gives a powerful flash when ignited. The light is very actinic, and suitable for taking photographs. Either mixture can be exploded by percussion, that with aluminium being specially sensitive and powerful, as shown by striking a little on an anvil, and is dangerous to handle in quantity.

Mixtures with potassium perchlorate are much safer, and quite effective. One such mixture contains three parts perchlorate with two parts of magnesium powder. It gives a high temperature, and is used for igniting thermite and other materials in bombs. It also requires careful handling.

Chlorate Mining Explosives.

All of the above-mentioned chlorate explosives are much too sensitive for use in large quantities in military operations. But a discovery made by Street in 1897, that if the chlorate mixture contained oils or fats its sensitiveness was greatly decreased, initiated an entirely new set of blasting explosives. The first, and amongst the best, are the cheddites, made at Chedde in France. They are mixtures of potassium or sodium chlorate with a nitro compound, and castor oil. A typical cheddite has the composition :—

Potassium chlorate	79
Di-nitro-toluene	15
Nitro-naphthalene	1
Castor oil	5

Cheddites are much used as blasting explosives. Potassium perchlorate is used in a number of similar mixtures of which permonite is an example. Some also contain nitroglycerine.

Blastine.—This is the most important military chlorate explosive, and vast quantities have been used in the present War. There are several varieties, but a typical military blastine has the following composition :—

Ammonium perchlorate	60
Sodium nitrate	22
Tri-nitro-toluene	11
Paraffin wax	7

It is made in the form of a soft yellowish, granular substance, which can easily be compressed. It is not very sensitive, but can be detonated by a moderate blow on an anvil. In practical tests rifle bullets have been fired through cartridges without exploding

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them, but it can hardly be considered safe under such a test, especially if the cartridge had a hard backing. It ignites easily and burns fiercely with a hot flame. In practice it is detonated by a fulminate detonator, and is a powerful high explosive, about equal to ammonal. Velocity of detonation over 4,000 metres per second.

Blastine is extensively used for military mines, and for charging bombs and grenades. The products of detonation do not contain any hydrochloric acid gas, and are not poisonous.

Permite.—This is a mixture intermediate between ammonal and blastine, and may be looked on as ammonal in which the expensive aluminium is replaced by zinc powder, the consequent diminution in power being compensated for by using ammonium perchlorate instead of the nitrate. It is made in several varieties. One has the following composition :—

Ammonium perchlorate	82
Zinc dust	10
Vaseline	5
Asphaltum Varnish	3

Some varieties have sulphur, and methyl alcohol and benzene as solvents.

It is used for the same purposes as blastine, and has about the same power. It is more sensitive to percussion. In form it is a greyish-brown powder.

All of the chlorate explosives require fulminate detonators, and for this reason, besides being too sensitive, are unsuitable for use as a H.E. shell filling. Rate of detonation 4,000 to 5,000 metres per second.

Mixtures of ammonium perchlorate and paraffin wax with combustibles such as aluminium powder or wood meal are also used, and are powerful high explosives.

Ammonium perchlorate explosives, like the corresponding ammonium nitrate mixtures, detonate best when in a porous form. Like these, too, they tend to set into a dense mass in store, especially when exposed to high atmospheric temperatures, and in that condition are very insensitive and may fail to detonate. They should not be exposed to direct sun's rays.

SOME MISCELLANEOUS MIXTURES.

Thermit, now an important munition of war, is in a class by itself. It is a mixture of about six parts of iron oxide with one part of aluminium powder, highly compressed. It has a very high ignition point, and requires a priming of a mixture of magnesium powder with barium peroxide or potassium perchlorate. When once ignited a fierce reaction takes place. The Al abstracts the oxygen from the iron oxide, liberating metallic iron and so much heat that the

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temperature is in the neighbourhood of 5,000°C., one of the hottest things on earth. It is used for charging incendiary bombs, and sometimes in a kind of shrapnel. A small explosive charge scatters the contents, which rain down bits of blazing iron, which will instantly set fire to anything capable of burning.

Coloured Lights and Flares.—These are mixtures of metallic chlorates and nitrates with combustible matter, and sometimes inert metallic salts. Shellac is one of the best combustibles, and sometimes sugar is used. Chlorates make the most energetic mixtures, but 50 per cent. or so of nitrate is usually added to make the mixture slower in action and safer to handle. The colour of the flame depends on the metal used. Thus :—

Barium compounds	give	green.
Strontium	,,	red.
Copper	,,	blue.
Sodium	,,	yellow, etc.

Many formulæ are in use ; the following are examples :—

Green Light.

Barium chlorate and nitrate	80 parts.
Shellac (or milk sugar)	20 ,,

Red Light.

Strontium nitrate and potassium chlorate ...	84 parts.
Shellac	16 ,,

Magnesium Lights.—Mixtures used for illuminating purposes in rockets or star shells consist of magnesium powder mixed with chlorates and nitrates, a little oil or wax being incorporated to slow the action and make it burn a longer time. Sixty-three parts of a mixture of potassium chlorate and barium nitrate, 35 of magnesium powder, and two of boiled linseed oil gives a good lasting light.

The Nitro Celluloses.

As early as 1832 Bracannot discovered that the action of nitric acid on starch and woody fibres converted them into highly inflammable substances. In 1838 Pelouze extended the experiments to paper, linen, and cotton. In 1846 Schönbein, the discoverer of ozone, used concentrated nitric acid and cotton wool, and called the resulting substance guncotton. A little later sulphuric acid was added to the nitric, and this mixture has been used ever since.

Schönbein gave demonstrations of the new explosive in England in 1846. The value of an explosive which was several times more powerful than gunpowder, and quite smokeless, was immediately recognized. Its manufacture was started the same year in England at Faversham, and also in France. A little later in Austria.

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Next ensued a series of disastrous explosions which could not be accounted for. The manufacture was stopped everywhere as being too dangerous.

About 1863 the late Sir Frederick Abel conducted a series of experiments at the Waltham Abbey factory which explained the cause of the explosions, and also how the substance could be made and kept safely. The researches were published in 1866—1867. Briefly they amounted to this :—

Cotton in its microscopic structure is made up of minute capillary tubes. During the process of nitration the tubes become filled with acid, and as they are practically waterproof the elimination of the acid by washing is a difficult matter, the amount of washing usually given being quite insufficient. Later it was shown that some sulphuric acid remains chemically combined with the cellulose.

In stored guncotton both free and combined acids set up a decomposition, with evolution of heat. The rise of temperature accelerates the rate, and when large masses are stored the temperature may at last reach the explosion point, which it did in many cases.

Abel showed that to eliminate the acid a prolonged series of boilings was necessary, these acting, partly mechanically by dissolving the acid, and partly chemically by decomposing the sulphate. Pulping the guncotton, by dividing it into infinitesimal fragments, facilitates the process, besides making it more easily manipulated into suitable forms for use.

The cotton used must be nearly pure cellulose. The natural impurities associated with it, which are of a fatty or resinous nature, form unstable nitro-compounds which hasten the decomposition of the whole.

Finally, as the guncotton still contains traces of free or combined acid, a preservative capable of combining with the products of decomposition must be incorporated with it. The guncotton will then be fairly stable, but still it has a limited life, the length of which depends on the temperature at which it is stored.

Acting on these principles Abel established a process for the manufacture of guncotton which, with some modifications, is carried out to this day. There are other forms of nitrocellulose which, with guncotton, form the most important military explosives of to-day, and are the basis of all smokeless powders.

Cellulose has the empirical formula $C_6H_{10}O_5$, and belongs to the class of bodies called carbohydrates, which includes starch, sugar, and gums. Any one of these will produce an explosive compound when treated with nitric acid. Cotton is the purest natural form of cellulose, and when treated with dilute boiling caustic soda, and chlorine, and afterwards well washed, is almost pure cellulose. Wood and other vegetable fibres contain large percentages of modified

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celluloses, such as lignose, oxycellulose, pectoses, and so on. As these are more chemically reactive than pure cellulose they can be removed by reagents, and most of them are removed in the process of preparing wood pulp for paper making. It has been shown that by a drastic treatment 40 per cent. of good cellulose can be obtained from a suitable wood, and from this a stable nitrocellulose can be obtained, although not quite so powerful as that from cotton. It is extremely probable that most of the German cellulose is now obtained from this source.

Action of Nitric Acid on Cellulose.—When cellulose is acted on by a mixture of nitric and sulphuric acids containing water either a mono, di, or tri nitrate may be formed, depending on the proportions of the acids and water present. Thus :—

(1). $C_6H_{10}O_5 + 3HNO_3 + nH_2SO_4 = C_6H_7O_2(NO_3)_3 + nH_2SO_4.3H_2O$.
Cellulose. Nitric acid. Sulphuric. Tri-nitrate.

(2). $C_6H_{10}O_5 + 2HNO_3 + nH_2SO_4 = C_6H_8O_3(NO_3)_2 + nH_2SO_4.2H_2O$.
Di-nitrate.

Similarly for the mono-nitrate. The H_2SO_4 combines with the water liberated in the reaction and serves to keep the concentration constant (within limits), but it also probably plays a much more important part.

The actual reactions which take place are certainly much more complicated than as represented, and although much research has been devoted to the problem it is still obscure.

Theoretically—

Tri-nitro-cellulose should contain		14.14	per cent. of N.
Di-	,,	11.12	,,
Mono	,,	6.77	,,

No one of these has been prepared pure. 13.92 per cent. of N has been obtained, but the substance was not stable. 13.5 per cent. appears to be the limit for a stable compound, and a good guncotton contains about 13 per cent. of nitrogen. Attempts have been made to account for the varying percentages of nitrogen by multiplying the formula of cellulose and assuming a large number of nitrates, but the results are not satisfactory.

Soluble and Insoluble Nitrocelluloses.—Some forms of nitrocellulose, especially the greater part of the highly nitrated guncotton, are insoluble in a mixture of alcohol and ether, while other forms are soluble. The lower nitrates are most soluble. It was therefore assumed that the tri-nitrate was the insoluble form, and that the lower nitrates were soluble. As 10—12 per cent. of guncotton was soluble it was assumed to be a mixture of insoluble tri-nitro with 10—12 per cent. of di-nitro. As the power of explosion of guncotton depends on the extent of nitration, for this reason, as well as the

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belief that the soluble variety was unstable, every effort was made to keep down the percentage of solubility.

But we now know that the solubility in alcohol-ether is largely a matter of temperature of nitration. The higher the temperature, up to about 40°C., the greater the solubility. The amount of water present is also a factor. Nitrocellulose containing 12.5 per cent. of nitrogen, and soluble in alcohol-ether, or at least completely gelatinized by it, is now made on an enormous scale, and constitutes 99.5 per cent. of N.C. smokeless powders, as well as being used in the new cordite.

All kinds of nitrated cotton retain their original structure and appearance, except that they are a little harsher to the touch. They can be spun into yarn or even made into cloth. When dry, N.C. is very inflammable, and burns rapidly when uncompressed. It can be detonated by percussion, and easily by fulminate.

Manufacture of Guncotton.—Practically the only improvement on the original Abel process is the use of the "displacement apparatus" for nitration, instead of the original earthenware pots where the cotton was allowed to soak in the acid mixture. This was invented by Nathan and Thompson of Waltham Abbey and is now generally used.

The figure shows a section of one pan, of which four form a set.

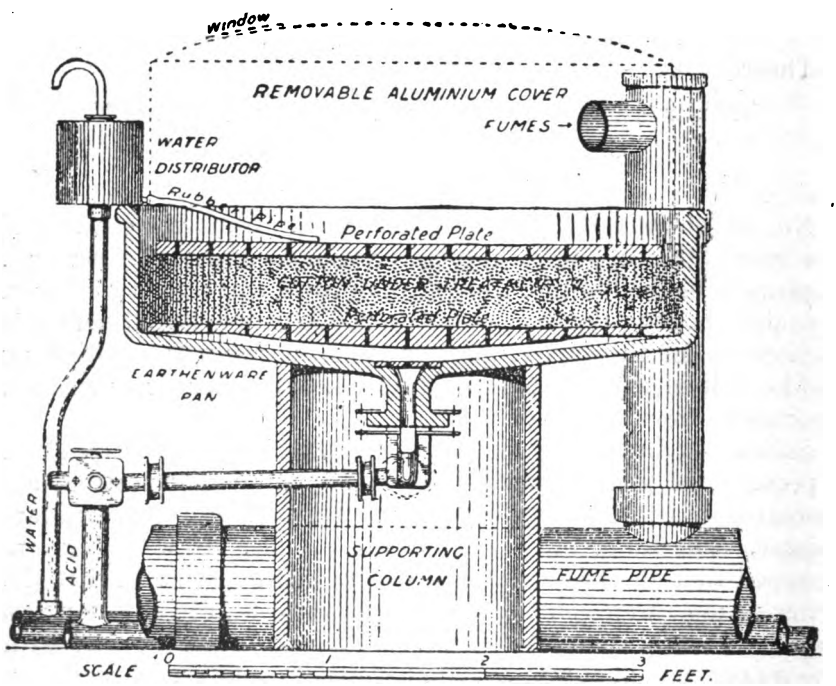

FIG. 1.—*Section showing the New Apparatus of Nathan and Thompson.*

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The pan is 3 ft. 6 in. in diameter by 10 in. deep, and is made of earthenware or acid-resisting iron. By means of valves the outlet can be made to communicate either with an acid supply, a waste acid receptacle, or a drain.

The acid mixture found to be best consists of three parts by weight or ordinary pure conc. sulphuric acid with one part of nitric. The mixture contains 8 per cent. of water. The details of the process of manufacture are given in any treatise on explosives. The following is an outline of the Waltham Abbey procedure.

About 650 lbs. of the cooled acid mixture is admitted to the pan, and 20 lbs. of the purified and prepared dry cotton immersed. A perforated aluminium plate is then put on top, and water run on to it to act as a seal and prevent the escape of fumes.

After $2\frac{1}{2}$ hours the acid is run off at the bottom slowly, and water run in on top at the same rate, so that the water displaces the acid, thus giving the name to the process. In $3\frac{1}{2}$ hours the nitrated cotton is free from surface acid, and ready for purification. The advantages over the old process are that it gives a better yield, of a more uniform and stable guncotton, besides saving time and labour, and involving less exposure of the workers to acid fumes.

The guncotton is next boiled in great vats which hold nearly a ton of it. There are 10 boilings lasting 50 hours, starting with long boilings of 12 hours, and ending with short ones of 2 hours. It is next pulped in a paper maker's beater, which cuts it into infinitesimal fragments. The pulp is washed in several changes of water.

When required for the manufacture of cordite the pure pulp is measured into moulds and subjected to gentle pressure, about 34 lbs. per sq. in., which removes much of the water and leaves the guncotton in primers firm enough to be handled. These are taken away to be dried.

When required for use as a demolition agent a mixture of caustic soda, lime water, and whiting is added to the pulp, sufficient to leave 1 to 2 per cent. in the finished article to act as preservative. The pulp is then moulded and pressed as before, but receives a final pressure of 5—6 tons per sq. in. which converts it into slabs. For land service 15-oz. slabs are the standard, and they are moulded with a central conical hole to take a 1-oz. primer. They are dipped in a solution of carbolic acid and caustic soda to prevent mould, and packed in metal cases which are hermetically sealed. They contain about 17 per cent. of water.

The primers are moulded and pressed in the same way as the slabs, with a central hole to take the detonator. Next they are dried down to 1—2 per cent. of moisture, then dipped in acetone to dissolve the surface and give it a waterproof glaze. They are packed very carefully in special tin tubes, each of which contains 1 doz. 1-oz.

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primers are the standard for land service. For the Naval Service slabs and primers of different weights are used.

Slabs of wet guncotton constitute the safest and one of the most effective demolition agents, and remain the standard of the R.E. With more than 13 per cent. of water guncotton is quite incombustible, and very difficult to detonate except by large charges of fulminate, or an ordinary detonator and a dry primer. For example, during the present War an 8-in. shell detonated in a wagon load of wet guncotton failed to explode it. The primers and detonators are carried separately. When detonated in good contact with the object to be demolished it produces intense cutting effect, even untamped, although there is little advantage in increasing the depth of charge above two or three slabs. With large charges tamping is an advantage. A guncotton slab will cut through its own thickness of iron, a necklace of primers tied round a good-sized tree will cut it down. The velocity of detonation is about 5,600 metres per second.

As guncotton contains insufficient oxygen for its complete combustion the gases contain 30 to 45 per cent. of carbon monoxide, and 15 to 20 per cent. of hydrogen. They are both inflammable and poisonous, and for this reason alone it is unsuitable for mining.

In practice the slabs are placed or secured in intimate contact with the object to be demolished, and with one another. A primer is inserted in one slab, and a detonator in the primer. A No. 8 detonator is used when firing is to be done by fuze, safety or instantaneous; a No. 13 electric detonator when the firing is done electrically, which is the best method but takes more time.

The firing of a charge I illustrate by firing a detonator in a safety iron box. Military mines are fired in the same way.

Guncotton was formerly used exclusively for torpedo warheads, marine mines, etc., but has now been largely replaced by T.N.T., and ammonium nitrate and chlorate mixtures.

Guncotton in Store.—Like all varieties of nitrocellulose guncotton decomposes on keeping, and the rate increases with the temperature. Hence it should be kept as cool as possible, and never exposed to the direct rays of the sun. In temperate climates it should be good for 20 years at least, but has a much shorter life in the tropics.

When guncotton shows signs of acidity, or brown fumes are seen, it shows that decomposition has proceeded far, and it is unsafe. When it dries it can be re-wetted without any deterioration. It can absorb 30 per cent. of water, but is then too insensitive. In the best condition it should just ooze moisture when pressed by the finger—15 to 17 per cent.

High Nitrated Soluble Nitrocellulose.—The manufacture of this substance is carried out in much the same way as that of guncotton, the only difference being in the composition of the acid mixture and

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the temperature of nitration. In one method the acids consist of a mixture of equal volumes of conc. sulphuric and nitric acid, and the nitration is carried out at 40°C. for half an hour. The product is washed and stabilized as with guncotton, and contains 12.4 per cent. of nitrogen. It is completely gelatinized by an alcohol-ether mixture.

In the manufacture of American nitrocellulose the acids have the following composition :—

Sulphuric acid	63
Nitric acid	22
Water	15

The nitration is carried out at 30—32°C. in an apparatus similar to that used in the Waltham Abbey plant, and the product is stabilized in much the same way. It contains 12.5—12.7 per cent. of nitrogen, and is completely gelatinized by alcohol-ether.

Contrary to former beliefs this soluble nitrocellulose appears to be as stable as guncotton, but not quite so powerful.

Collodion Cotton (also called pyroxylin).—This variety is made by using a still weaker acid mixture, and nitrating at a still higher temperature. In one formula used the acid contains 35.5 per cent. of nitric acid, 44.5 per cent. of sulphuric, and 20 per cent. of water by weight. The nitration takes place at a temperature of 55°C., and lasts half an hour. The product is well washed, but not boiled or pulped.

It contains about 11 per cent. of nitrogen, and dissolves readily in an alcohol-ether mixture (about 1 part in 30 of the mixture by weight) forming a clear solution called collodion. This leaves a perfectly transparent film when poured on a surface and allowed to evaporate. It is much used in photography, and in surgery for covering wounds. Collodion cotton dissolved in camphor forms celluloid. Dissolved in nitroglycerine it forms blasting gelatine, a valuable explosive. Mixed with camphor and castor oil collodion is used for coating incandescent mantles to preserve them during transport.

(*Note.*—A mixture of 1 vol. of alcohol with 2 vols. of ether is the best solvent for N.C.).

Nitroglycerine Explosives.

Nitroglycerine was discovered by Sobrero in 1847, and still remains the most powerful explosive in practical use. It is of great military importance, and is a constituent of our standard smokeless powder.

Glycerine, $C_3H_5(OH)_3$, is a constituent of all animal and vegetable fats and oils, which are the only source of supply on the large scale. The various tropical products, palm oil, cocoanut oil, etc., are sources of glycerine.

When these fats or oils are boiled with caustic soda or potash (lye),

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they form a mixture of glycerine and soap, and this is probably one of the oldest chemical processes.

$$(C_{18}H_{35}O_2)_3C_3H_5 + 3NaOH = C_3H_5(OH)_3 + 3C_{18}H_{35}O_2Na.$$
Mutton fat. Soda. Glycerine. Soap.

Pure glycerine suitable for the manufacture of explosives is difficult to separate from the soap, so other processes in which the fats are acted on by high-pressure steam, or lime, are used, the products being the free fatty acid or a lime soap, and glycerine. Hence, when fats are scarce, and glycerine is required, soap is also likely to be scarce. About 10 lbs. of fat are required to produce 1 lb. of glycerine.

When glycerine is required for conversion into nitroglycerine it must have a high degree of purity, and sp.g. not less than 1.26. The acid mixture found best for the nitration contains 1 part of HNO_3, sp.g. 1.5, and 1.7 parts of H_2SO_4 containing 96 per cent. of pure acid, by weight. When 1 part of glycerine is poured into 8 parts of the acid mixture, previously cooled to a temperature of 15°C., and stirred up with it, the nitrating action takes place immediately. On standing a few minutes the N.G. separates and floats on the acids as a clear liquid. The equation representing the action is :—

$$C_3H_5(OH)_3 + 3HNO_3 = C_3H_5(NO_3)_3 + 3H_2O.$$
Glycerine. Nitric acid. Nitroglycerine. Water.

The sulphuric acid combines with the water liberated by the reaction, and maintains the concentration of the HNO_3. It has no further action.

The N.G. may be separated by pouring the whole mixture into a large volume of water, when the acids dissolve and the N.G., being insoluble, sinks to the bottom. This is the old method and most suitable on the small scale. On the large scale the N.G. is run off from the top through a suitable opening. The operation is perfectly safe if care be taken not to allow the temperature to rise above about 30°C., which necessitates water-bath cooling. Otherwise a decomposition sets in, indicated by the appearance of brown fumes, and may end in a dangerous explosion.

The N.G. only requires to be washed quite free from every trace of acid, and is ready for use. While in contact with acid it is dangerously sensitive and unstable.

MANUFACTURE ON THE LARGE SCALE.

The figure represents diagrammatically the arrangement of the apparatus used at Waltham Abbey.

Owing to its dangerously sensitive nature, especially when in contact with acid, the greatest possible precautions are taken in the manufacture of nitroglycerine, and accidents are rare. It is made to flow from point to point by gravity during the operations. The

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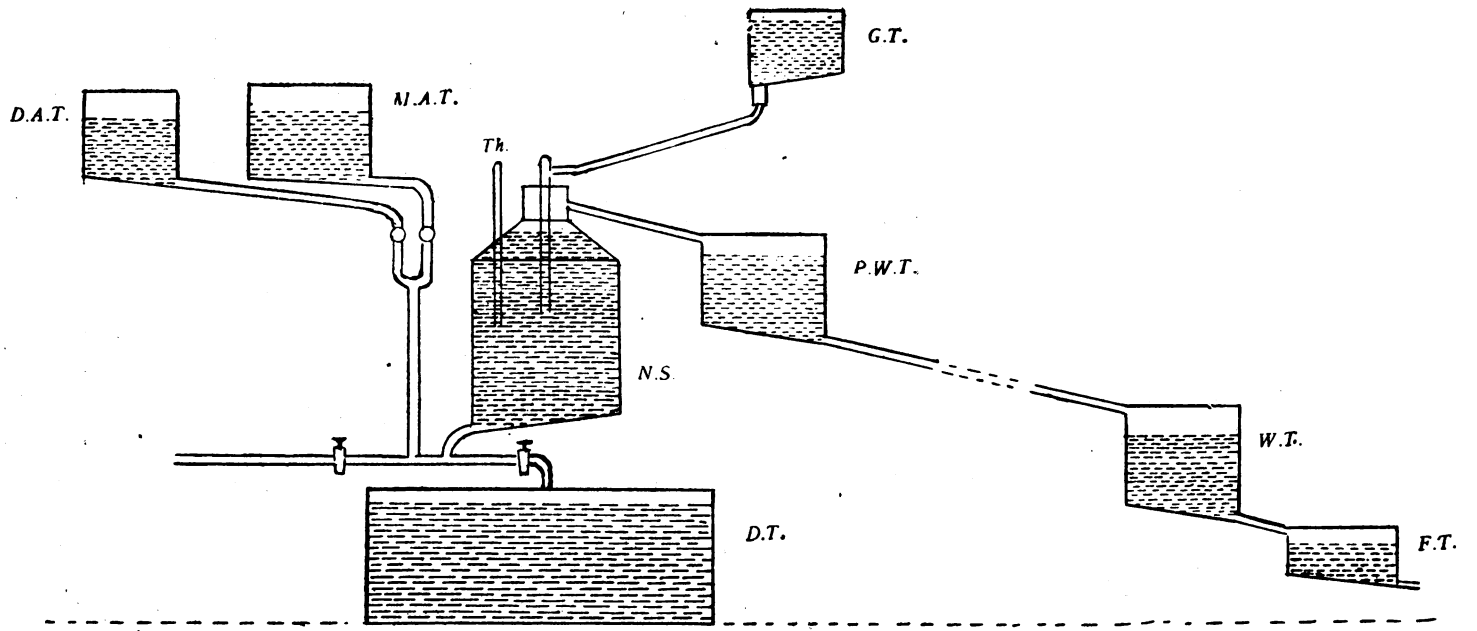

FIG. 2.—*Waltham Abbey Nitro-glycerine Plant. Displacement Process.*

D.A.T.—Displacing acid tank.
M.A.T.—Mixed acid tank.
G.T.—Glycerine tank.
N.S.—Nitrating separator.
P.W.T.—Pre-wash tank.
W.T.—Washing tank.
D.T.—Drowning tank.
Th.—Thermometer.
F.T.—Filtering tank.

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temperature is kept low, and watched carefully by means of thermometers immersed in the liquid. All stirring is done by compressed air issuing from perforated pipes laid round the bottom of the vessels, and during nitration the liquid is kept cool by coils of pipes through which cold water is circulated.

A full description of the process of manufacture can be found in the various text books ; briefly it is as follows :—

The charge of 4,000 lbs. of nitrating acid is admitted to the nitrating vessel, and cooled to 16°C. The charge of 500 lbs. of glycerine is then injected in fine spray by means of compressed air, and the acids are kept thoroughly agitated by air bubbling through. The temperature is watched, and not allowed to rise above 22°C. If decomposition sets in, as shown by red fumes and a rise of temperature, the whole charge is shot into a drowning tank filled with water underneath the nitrator. This applies to subsequent operations as well.

When the charge has been nitrated, which takes about 40 minutes, it is allowed to stand, and the N.G. separates and floats on the acids. Waste acid from another tank is then admitted to the nitrator to raise the level of the liquid, and the N.G. flows off through a side pipe into the pre-wash tank, which is half filled with water. Here it is washed three times with water, and once with water containing some washing soda. It is then run through a gutter into the washing house proper, where it is washed three times with warm soda water, and finally with plain water, which leaves it acid-free, and practically pure except for a little water.

The water is skimmed off after each washing, and all stirring is done by compressed air.

Finally, it is filtered through flannel bags filled with dry common salt, which removes all scum and absorbs moisture. The N.G. is then pure and ready for use.

Properties of Nitroglycerine.—Nitroglycerine is a slightly yellowish transparent liquid, sp.g. 1.6. It is insoluble in water, but dissolves in alcohol, ether, acetone, and many other organic liquids. It is very poisonous, and gives violent headaches even when placed on the skin. It has a powerful action on the heart, and is used as a drug. Many cases of N.G. poisoning occurred in the S.A. War through soldiers chewing cordite.

The liquid is difficult to ignite, and a taper may be extinguished by dipping it into nitroglycerine. But if a filter paper or some cotton wool be soaked in the liquid it burns quietly, but rapidly, with a greenish-edged flame.

To show its explosive properties ; put a drop on a filter paper and strike it with a hammer on an anvil. It detonates with a loud report and blows the paper to shreds. Put a drop on a smooth metal plate, and heat it fairly rapidly. It gives off vapour at 100°C.,

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boils at about 180°C., but begins to decompose. Red fumes appear, and when the temperature reaches about 180°C. it detonates completely with tremendous effect. When the experiment is successful a hole is blown in the plate and the pieces turned right back so as to touch the reverse side.

Fulminate of mercury detonates it completely (about 2 grams will detonate an unlimited amount) with tremendous disruptive effects. A small charge of fulminate sets up an inferior kind of detonation with a velocity of 1,500—2,000 metres per second, but with complete detonation the velocity is 7,500—8,000 metres per second.

N.G. is the only explosive compound in use which contains sufficient oxygen for its complete combustion, which explains its great power. The products of detonation contain free oxygen, and are in accordance with the equation :—

$$2C_3H_5(NO_3)_3 = 6CO_2 + 5H_2O + 3N_2 + O + \text{Heat.}$$

It freezes at about 4°C., and forms crystals. In this form it is very sensitive, and merely squeezing crystals between the fingers may explode them, but it does not carry the detonating wave well, and with large charges a great portion may be blown away and escape detonation altogether. This applies to all the N.G. explosives. All require to be thawed before use, which makes them inconvenient for use in cold climates.

Nitroglycerine is the most powerful explosive in use, but in the liquid form is inconvenient and too sensitive to be handled safely. It is now always absorbed in some substance which enables it to be used in a suitable plastic form.

There are two main classes of N.G. explosives in present use.

(1). *The Dynamite Class.*—The N.G. is absorbed in some porous solid, so that it can be moulded into cartridges. The solid may be an inert substance, or it may be an explosive itself, usually a mixture resembling a primitive gunpowder.

(2). *The Blasting Gelatine Class.*—These have as their basis blasting gelatine, and range from the pure substance to mixtures of mild explosives with varying percentages of it.

Dynamite No. 1, the original dynamite invented by Nobel in 1866, consists of three parts of N.G. absorbed in one part by weight of kieselguhr, a diatomaceous earth. The guhr is calcined and sifted, and is a fine powder free from grit. Up to 2 per cent. of magnesium, sodium, or calcium carbonates are added as preservatives, also ochre to colour it, and sometimes barium sulphate and similar inert substances. It forms a plastic mass, brown or reddish coloured, and is made into cartridges which are wrapped in parchment paper. It is much less sensitive to percussion than free N.G., and safer to handle. When ignited in small quantities it burns fiercely but does

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not explode. It is readily detonated by a fulminate detonator, and as might be expected its shattering power is about three-quarters that of pure N.G.

Dynamite No. 2 is a mixture of 18 parts N.G., 71 of potassium nitrate, 10 charcoal, and 1 of paraffin wax.

Lithofracteur contains 50 parts of N.G., and 50 of a mixture of kieselguhr, wood meal, barium nitrate, and a little sulphur.

Carbonite contains 25 parts N.G., and 75 of a mixture of wood meal, potassium and barium nitrates, and a little sodium carbonate.

There are many similar mixtures in use, especially in America. Generally speaking the smaller the percentage of N.G. the slower they are in action, and hence the greater the rending and lifting, and the less the shattering effect.

All the dynamites are disintegrated by water. They exude their N.G. which may become dangerous. All freeze at low temperatures, in which state they behave erratically, and are dangerous to handle. They require to be thawed before use, which should be done carefully in the proper apparatus, and not in the rough method of some miners (exposing cartridges to the heat of a fire) which has led to many fatal accidents.

Blasting Gelatine is another valuable explosive invented by Nobel. It consists of five to seven parts of collodion cotton dissolved with the aid of heat in nitroglycerine, with the addition of a little sodium carbonate as preservative. It forms a stiff jelly which does not exude N.G. in contact with water, and is stored under water. It is made into cartridges like dynamite. It is much less sensitive than pure N.G., and comparatively safe to handle. Requires a strong detonator, as jellies do not transmit the detonating wave well, and is as powerful as pure N.G., the excess of oxygen in this substance supplying the deficiency in the collodion cotton. It is the most powerful explosive in use. Rate of detonation 7,700 metres per second.

There are many mixtures in use containing blasting gelatine as their base, all milder in action but very powerful.

Gelatine dynamite contains 80 per cent. of blasting gelatine, and 20 per cent. of a mixture of wood meal, potassium nitrate, and guncotton.

Gelignite contains 60 per cent. of blasting gelatine, and the remainder as with gelatine dynamite. It is a very powerful H.E. with great rending and lifting effect, and much used as a blasting explosive in Britain.

There are numerous other explosives with fancy names, very similar to the above.

Military Uses of N.G. Explosives.—Nitroglycerine blasting explosives are not Service explosives, but all military engineers are expected to be familiar with their properties and uses. Large

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quantities are kept in mining districts, and in war time they are freely used in back areas. They are not suitable for use near the front line, as they are liable to be detonated by a moderate shock, such as the stroke of a bullet.

Cartridges of these explosives make excellent primers for the detonation of large charges of the safety explosive mixtures.

Military Smokeless Powders.

A gunpowder, to be smokeless, must contain no mineral matter which would produce solid products of combustion. This excludes all mineral nitrates, except ammonium nitrate, and attempts to use this as a substitute for saltpetre were defeated owing to its hygroscopic nature.

Before 1860 von Lenk in Austria had provided several field batteries with guncotton cartridges. In order to slow its rate of combustion it was twisted into threads, and compressed, but although it then burns slowly under atmospheric pressure the high pressures in a gun finds out the pores. The flame gases penetrate, the explosive is then so violent that the gun is liable to be destroyed, as was soon found.

In 1875 Shultze powder appeared. It consists of nitrated grains of purified wood, impregnated with nitrates. It was still porous, but the density was so great that the rate of burning was slow enough to make it suitable for shot guns.

It was some time before it was realized that if the rate of combustion was to be under control the porosity of the substance must be completely destroyed; that no amount of mechanical pressure will do this, and the only way is to completely dissolve it, or at least completely gelatinize it by means of a solvent. When the solvent is evaporated the substance will then be impervious to flame gases at the highest chamber pressures, and burn regularly from the surface only.

The first to realize and make practical use of this fact was Mr. Walter H. Reid, who with D. Johnston took out a patent in 1882 for E.C. powder. This consisted of grains of guncotton impregnated with nitrates, and treated with alcohol-ether. As the guncotton contains a fair amount of soluble N.C. this was gelatinized and formed an impervious coating and binding for the other portions. The result was a good, almost smokeless powder, which is in use to this day.

With the truly gelatinized explosive the time of combustion of a charge can be regulated by the diameter of the cord or stick, and so adjusted to the various sizes of guns, or rather to the length of the gun, so that the whole charge may be consumed just before the shell emerges from the muzzle. It is also necessary that the rate of production of gas should increase as the shell moves forward in

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the bore and the space enlarges, so as to maintain the pressure. This is partly brought about by the rate of burning of cordite increasing with the pressure. Taking Mansel and Petavel's equation $V=a_0+ap$. Where a_0 is the rate of burning at no pressure, a=Const. a_0=.5 cm. for cordite and a=0.018 cms. Therefore in a field gun where the maximum pressure=15 tons per sq. in.=2,240 atmospheres, roughly, the cordite commences burning at the rate of .5 cm. per second, and at 40 cms. per second at highest pressure.

But the rate of gas production depends also on the surface exposed over which combustion is taken place. With a cylindrical rod the surface diminishes as combustion proceeds. With a flat strip it is practically constant, and the surface is large. With a tube or perforated cylinder it increases as the interior burns away. Hence the various forms, cords, strips, tubes and flakes, of which specimens are shown.

There are two varieties of smokeless military powders in use at present. (1) *Nitrocellulose Powders*, which consist of 99.5 per cent. of gelatinized nitrocellulose, and .5 per cent. of a preservative, and (2) *Nitroglycerine Powders* which are gelatinized mixtures of nitro-glycerine and nitrocellulose, with a few per cents of a stabilizer.

American Nitrocellulose Powder, N.C.T., is typical of the first class. It is made from soluble nitrocellulose containing about 12.5 per cent. of nitrogen. The purified nitrocellulose pulp is freed from water by pumping alcohol through it. Ether is then added to gelatinize it, and ½ per cent. of di-phenylamine to act as stabilizer, and the whole incorporated for about three quarters of an hour, then pressed until it is a block of stiff colloid. This is pressed by hydraulic pressure through a die arranged to leave one or more perforations, and is cut into short lengths as it issues. For field guns the rods have one perforation; for larger sizes they have seven perforations. For a gun such as the 60-pr. the rod is 14 mm. in length and 5 mm. diameter, and has seven perforations. Hence the name N.C.T. It is also made in square flakes.

The greater part of the solvent is afterwards dried out, but from 3 to 6 per cent. remains as a constituent, as without it the powder is too brittle, and the rods are liable to break up and give unduly high pressures.

N.C.T. is a good powder and fairly stable. It is the weakest of the smokeless powders. Charges must be about 16 per cent. heavier than with cordite to give the same muzzle velocity, but as this is due to the lower temperature of the gases there is less erosion, and the guns have a longer life. It gives more smoke than cordite, but a less muzzle flash, and there is less danger of a back flash. It is hygroscopic to some extent, and must be protected from atmospheric moisture, as absorption of moisture alters the shooting.

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N.C.T. is now much used in our Service for guns and howitzers, the charges being adjusted to give the same m.v. as cordite M.D.

German N.C. powders are very similar. The rifle powder is made in small flakes which are graphited.

French N.C. powders are different. Poudre B is made from a mixture of guncotton and soluble nitrocellulose. The alcohol-ether used as solvent dissolves the soluble N.C., and this coats and encloses the insoluble part. It has not so good a history as N.C.T. and cordite. The loss of the *Liberté* in 1911, and the *Jéna* in 1907, was undoubtedly due to spontaneous combustion of Poudre B, but this was probably due to other causes than inherent instability.

Russian powders were very similar to American N.C.T., but are of no interest now, since Russians have forgotten their use.

CORDITE.

Cordite Mk. I. was for long the sole British propellant. It was the result of a series of experiments carried out under the direction of the late Sir Frederick Abel, and Sir James Dewar, and its manufacture was commenced in 1889. It was based on Nobel's discovery that when nitrocellulose and nitroglycerine were thoroughly incorporated and gelatinized the sensitiveness of both were diminished, and the resulting substance formed a safe and powerful smokeless powder. Nobel's powder was ballistite, which contained 50 parts of collodion cotton dissolved in 50 parts of nitroglycerine, with a small percentage of camphor added as stabilizer. The collodion cotton was objected to as being unstable, and the camphor as volatile. The composition decided on was N.G. 57 parts, guncotton 38, and mineral jelly 5. Acetone was used as the solvent. The mineral jelly (vaseline) was added to modify the violence of the explosion and act as a lubricant for the bore. But later it was found that it was completely burnt up, and also that instead of being a pure paraffin, as supposed, it contained unsaturated hydrocarbons, and was an efficient stabilizer.

Cordite Mk. I. is a very powerful propellant, but owing to the high temperatures produced it is very erosive, and as the result of the S.A. War a modified cordite, "Cordite M.D." was introduced. It has the composition, guncotton 65, N.G. 30, mineral jelly 5. Its power is about 10 per cent. less than that of Mk. I., but the guns last three times as long. Cordite M.D. is the standard British propellant, although others are used at present.

The following is a brief outline of the manufacture :—

The guncotton, lightly pressed into cylindrical primers containing 50 per cent. of water, is dried in air at 40°C., until the water is reduced to ½ per cent. It is then weighed into rubber-lined bags and the charge of nitroglycerine poured on. The two are worked by hand into a paste which is quite insensitive compared with either of its constituents. The cordite paste is put into a kneading machine,

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acetone is added, and incorporated for about three hours. Then the vaseline is added and more acetone, and it undergoes a further incorporation, forming "cordite dough." The dough is pressed hydraulically through dies, and issues as cords, strips or tubes. The diameter of the rods and thickness of the tube walls varies from half an inch to one-hundredth of an inch. The acetone is driven off by exposure to warm air, which requires from 3 to 30 days.

Cordite varies in colour from light yellow to dark brown, depending on the vaseline. It is one of the best and most stable of smokeless powders, but like the others is decomposing from the day it is made, and requires care in store and frequent inspection. Different sizes are distinguished by numbers which give the diameter in hundredths of an inch in the case of sticks, and the outer and inner diameters in the case of tubes. Thus: Cordite M.D. $3\frac{3}{4}$. Cordite, M.D.T. 20—10. For strips the numbers give the width and thickness.

In store cordite should be kept cool and not exposed to the direct rays of the sun. In ships the magazines are artificially cooled. When cooled below about 6°C. the N.G. freezes, and appears as an exudation on thawing. The cordite is said to "sweat." The N.G. is reabsorbed on standing. Sweating cordite should be handled carefully, but may be fired in this condition. Water does not injure it, but it should be dried before use.

There are other modifications of cordite. One is similar to Cordite, M.D., except that a mineral jelly containing a larger percentage of unsaturated hydrocarbon, is used to increase the stability. In a new modified cordite soluble nitrocellulose is used instead of guncotton, and alcohol-ether is used for the gelatinization instead of acetone. It contains a larger percentage of nitroglycerine than Cordite, M.D., but is very similar, although not quite so powerful.

Ballistite is also used as a military powder. The original ballistite contained 50 parts N.G., and 50 of collodion cotton gelatinized by heat, with addition of $\frac{1}{2}$ per cent. of di-phenylamine as stabilizer. It is rolled into sheets and cut into small square flakes. It is the most powerful of all the smokeless powders, but the most erosive, and only suitable for howitzers where the chamber pressures are low. A modified ballistite has been introduced in which the more stable highly nitrated cellulose is used, and the percentage of nitroglycerine diminished. It has the same characteristics as the other, but not quite so erosive. The flakes are sometimes graphited. Specimens are shown.

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WEIGHTS AND MEASURES.

A FIELD Company Commander writes :—

In the May number of the *R.E. Journal*, some queries were raised as to the list of weights of vehicles of a Field Company on the march, sent in by my predecessor in this unit.

Certainly, the circumstances were peculiar at the time, as it was immediately after our arrival in this country, when there was no extra transport available in the way of lorries. Consequently all the extra stores, that have to be carried nowadays by units in the field, had to be taken along on our equipment transport. Shortly afterwards the hiring of local vehicles—bullock wagons, etc.—was authorized, and the loads were proportionately reduced. Fortunately, the country was extremely flat.

These extra stores—for which no allowance is made as regards transport—were, when these weights were taken :—

Two blankets per man,
Horse rugs,
Two days' forage and rations,
Leather jerkins and fur coat,
Bridging vehicle fittings for engine draught,

to mention the chief ones.

In addition, it should be remembered that box respirators and steel helmets have been added to the equipment carried " on the man."

Some of the Infantry units tried to ease their transport by making the men carry blankets, jerkins, etc. ; but the results were fatal, enormous numbers of men falling out from exhaustion. The Division was marching an average of about 15 miles a day.

I can vouch for the facts, as I was Adjutant of the Divisional Engineers then.

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SUN-SCREENS IN SKY-LIT BUILDINGS.

By A C.R.E.

SKY-LIT buildings not provided with blinds and used as temporary offices—many of which no doubt have been taken for this purpose in the U.K.—are apt to be uncomfortably hot in the summer owing to direct sunlight and irrespective of possibly defective ventilation.

Obscuring the glass by painting or otherwise is open to the objection that it cuts off too much light on a dull day. Blinds are expensive and are liable to get out of order, which in a high-roofed building may be awkward.

It was decided in two cases to fix sun-screens. Screens should cause minimum interference with diffused light and ventilation, should give maximum protection against direct sunlight, should be good reflection of light, and should be cheap.

These conditions are fulfilled by a material known as "Bolton Sheeting" fixed as described later to the roof trusses; this material is white, reasonably opaque, and the price in 1917 worked out to about 1s. per square yard.

CASE A.

The building is favourably oriented, its axis being only 5° from true east and west (*Fig.* 3). The skylight is glazed at the sides (which open) as well as on top.

Screens (see *Fig.* 1) were designed to be fixed as follows:—

Longitudinal, AG and BD; cross,—at every truss except the one at west end—FEDB. Instead of screen BD one fixed to the strut DC would have given equal protection but the former was chosen both on account of ease in fixing and as being less attractive of dust.

When the sun is on the meridian the longitudinal screens give complete protection from direct sunlight (*Fig.* 1); and this is the case till 3 p.m.* At 4 p.m. (*Figs.* 3 and 4) the cross screens come into

* *Note.*—Unless otherwise stated time is the Summer Time of the locality and the sun's position is that at its maximum north declination.

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FIG. 1. SECTION L

FIG. 5. LONGITUDINAL SECTION (CASE A) at 5" 35" P.M.

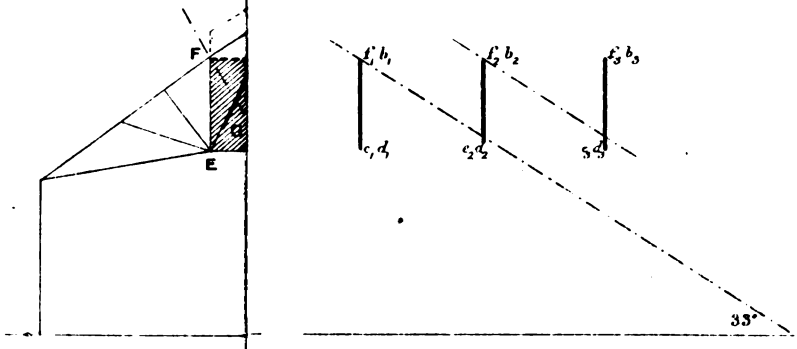
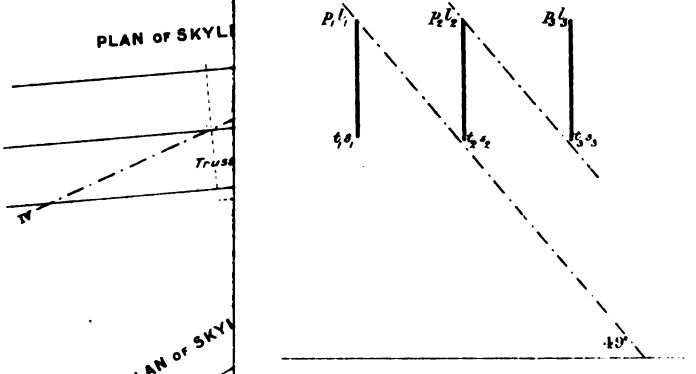


FIG. 6. LONGITUDINAL SECTION (CASE B) at 3" 45" P.M.



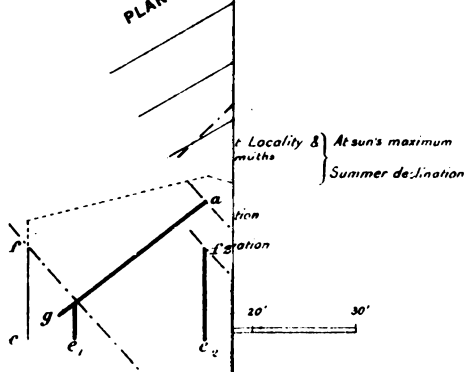


FIG. 4. SECTION A

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action and at that time there will be an unprotected area indicated by the rectangle *xy* in *Fig.* 3; this will disappear when the sun's north declination is 15, *i.e.* towards the middle of August. At 5.35 when the sun is in the direction of the axis of the building the cross screens give complete protection (*Fig.* 5).

The screens in this case cost about 6s. per foot-run of skylight. They have been up nearly a year and have required no attention.

Case B.

Here the orientation is not so favourable, the axis of the building running N. 60 E. and S. 60 W., but the trusses are at closer intervals, 10 ft. 6 in. instead of 12 ft. The skylight is glazed on the top only, the sides are of wood, louvered for ventilation.

Screens proposed are: longitudinal—KQ and NR; cross—PTSL, the bottom of this screen to be fixed to a wire fastened to the junctions of small struts and tie rods.

It will be seen that at 2 p.m. (*Fig.* 7) the longitudinal screens do not give complete protection there being a gap, *n o*, which will not disappear until the middle of August; if found necessary the longitudinal screen NR can be extended 2 ft. 6 in. to S (*ns*, *Fig.* 7) which would effectually seal this gap. At 3 p.m. there is an unprotected area indicated by the rectangle *wv* (*Fig.* 3); at 3.45 p.m. the sun being in the direction of the axis of the building the cross screens are too short by 6 in. to give complete protection.

The cost of these screens is about 12s. per foot-run of skylight.

Calculations.

To determine the amount of protection given by screens it is necessary to know the latitude and longitude of the locality and to find the sun's altitude and azimuth. This can be done graphically or by calculation.

Formulæ are:—

$$\tan A = \frac{\tan t \cos N}{\sin(\phi - N)}, \quad \tan z = \frac{\tan(\phi - N)}{\cos A}$$

$$\tan N = \tan \delta \sec t$$

where A=azimuth, t=hour angle, ϕ=latitude, $z = 90° - h$ (the altitude), δ=declination.

The following table is sufficiently correct for this purpose. Due allowance must be made for longitude and Summer Time—*e.g.* in W. Long. 8° an hour angle of 3^H would correspond to 10.32 a.m. and 4.32 p.m. (neglecting the equation of time which in summer is small).

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TABLE OF ALTITUDES AND AZIMUTHS AT SUN'S MAXIMUM NORTH DECLINATION.

Hour Angle.	N. Lat. 58°		N. Lat. 54°		N. Lat. 50°	
	Alt. Deg.	Az. Deg.	Alt. Deg.	Az. Deg.	Alt. Deg.	Az. Deg.
0	55½	0	59½	0	63½	0
1	53½	23	57½	27	61	29
2	49	45	52½	48	55	52½
3	43	62	45	66	47	70
4	35	77	36	80	37	83
5	27½	90	27½	92	27	94
6	18½	103	18	104	17½	105

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CLIMAX OF TWO GREAT WARS.

By J. HOLLAND ROSE, LITT.D.

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AT no time during the present War have the prospects of the British people been so gloomy as they were after the collapse of Austria in the Wagram Campaign of the year 1809 and the disgraceful Walcheren expedition of that autumn. It may be well to outline the situation in the years 1810–11 and to suggest comparisons at some points with that of the far greater war against the Central Empires and their Allies. In this article I attempt to form estimates on military and naval affairs at the two periods, and in a subsequent article to treat questions of food supply, commerce, and financial stability.

The defection of Russia has brought about a state of affairs not unlike that which Napoleon's triumph over Austria produced in 1809. Thenceforth, up to the end of 1811, he threw his whole strength into the West. In 1810 a veteran army under Masséna swept through Spain and Portugal, and pinned Wellington's forces to the Lines of Torres Vedras. The tenacious British resistance (far from appreciated at the time) saved from utter ruin the cause of the Portuguese and Spanish "Patriots," inaugurated a time of balance in the Peninsular War, and encouraged the Tsar, Alexander I., to the independent fiscal policy which brought about the French invasion of Russia in 1812. Thus the years 1810–12 form the crisis of the Napoleonic War. Without Torres Vedras, there would have been a timorous peace, an unchallenged French ascendancy, broken by no retreat from Moscow, no Leipzig, no Waterloo.

The obedient journalists of Berlin have asserted that the great German push which began on March 21st, 1918, can be more than once repeated; that they do not rely chiefly on the submarine campaign, but will force a military decision. In a general way, therefore, the present push may be compared with the effort of Masséna; but Germany confronts Allies who equal her in determination and excel her in man-power, money, and material. She controls a central mass of territory and possesses an admirable military organization—advantages possessed in a unique degree by Napoleon over his feeble opponents of 1810–11. But her mass, like his, is gripped by sea power; and she, any more than he, cannot escape from its economic pressure by subjecting Russia as he did at Tilsit

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in 1807. Indeed, the more the Teutonic yoke galls the Russians, the more likely are they to cast it off at the first opportunity. The more intelligent Germans blame their Government for imposing humiliating terms on Russia, just as Talleyrand censured Napoleon for alienating public opinion in 1811–12. But the Germans persist, even as he persisted. Early in 1812 his nervousness as to the East prevented him sending into Spain the forces needed for ending the war. Even so, the Germans persist in their penetration of Russia. Sooner or later, then, sympathy must reawaken among the Russians with their former Allies, just as in the winter of 1811–12 Alexander I. based his resistance to the Napoleonic decrees on his confidence in Wellington's indomitable resistance, while the duke fought his uphill fight with the more spirit because he foresaw the Russo-French rupture. *Adsit omen!*

As the Berlin Press assures the world that the time is at hand when the war-will of the Western peoples must collapse, it may be well to recall the odds against which our forefathers fought. The census of 1811 gave the population of Great Britain as 12,596,803 souls. That of Ireland in 1821 was 6,801,827; and in 1811 it may be reckoned at about 6,250,000. The numbers of the white population in our chief colonies are not known until the following dates :— Canada, 1,172,820 in 1844; New South Wales (inclusive of what is now Victoria), 36,598 in 1828; Van Diemen's Land, 12,303 in 1824; Western Australia, 2,070 in 1834; South Australia, 17,366 in 1844; New Zealand, about 3,000 or 4,000 in 1847; Cape Colony, 68,180 in 1839. In 1811 these figures would be about one-half of those just presented. Consequently, we then had no military succour from the British race beyond the seas; and, owing to the disputes with the United States and the Dutch, Canada and Cape Colony (not to speak of India) needed considerable garrisons from the motherland. It is well, then, to realize that the British race within the Empire (including the Irish, but excluding the French-Canadians and the Dutch of Cape Colony) numbered less than twenty millions in the year 1811. Capt. C. W. Pasley, R.E., in his *Essay on the Military Policy of the British Empire* (1811), reckons only Great Britain as counting in the War, and, estimating the population of the Napoleonic Empire and vassal States at 77,000,000 souls, concludes that the odds against us were more than five to one. Probably he exaggerates the hostile numbers and underestimates our own; but, after Napoleon's annexations of the Papal States, Illyria, Holland, and N.W. Germany (as far as Lübeck), the French Empire must have included nearly 60,000,000 souls. This, however, is not all. In June, 1812, Napoleon marshalled for the Russian campaign 147,000 Germans from the Confederation of the Rhine, and some 80,000 Italians, 60,000 Poles, and 10,000 Swiss, besides exacting contingents of 50,000 from the quasi-dependent States, Austria and Prussia. If we include all the

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lands which furnished the Emperor with man-power, Pasley's estimate of the odds is within the mark—at least, for 1811.

It is needless to point out the sharp contrast afforded by the present struggle. Probably the white population of the British Empire now approaches—or even equals—that of Germany, about 68,000,000. The deficiencies of the Allies are in their scattered positions and their military unpreparedness. But in 1811 the British and the Spanish and Portuguese patriots were still more deficient by comparison with Napoleon. He had the great advantage of inheriting a system of national conscription founded by the French Jacobins in August, 1793, and developed more systematically in 1798. He applied this system to his vast Empire, and expected vassal princes to supply almost as large a quota. True, by the year 1810, warlike enthusiasm had declined, and bands of refractory conscripts had to be hunted down. The levies which he exacted from his vassals were half-hearted, only the Poles and the North Italians fighting with enthusiasm. Still, love of glory, hope of plunder, or the longing to secure a lasting peace impelled the mass forward. As Count Ségur says: "There was not a hope which Napoleon could not flatter, excite, and satiate. . . . A war was often only a battle or a short and brilliant excursion." Such, too, is the Prussian tradition, based on the triumphant wars of 1864, 1866, 1870.

To break down the moral which in 1810–11 still inspired the best of Napoleon's troops was a stupendous task; but Wellington impaired that moral at Busaco, wore it down at Torres Vedras, displayed the full fighting strength of the British soldier at Badajoz, and his superiority in the mighty clash of Salamanca (July, 1812). Even so, in the present War, the Allies, owing, first, to lack of numbers, and then of thoroughly trained troops, have been confined mainly to a defensive strategy. The Germans, also, like Napoleon, having the advantage of inner lines of operation, could adopt his methods which so often won a decisive triumph in a single campaign. Considering their superiority in numbers, equipment, and position in 1914, they cannot be pronounced brilliant pupils of the great commander.

It is well to realize how slowly and awkwardly the British military machine worked in Wellington's day. Nor must the fault be ascribed solely to the Government; it must accrue to the nation as a whole. Take the following jottings of Lord Uxbridge's agent at Plasnewydd in August, 1807, when England stood entirely alone: —

"Our regular army is now to be increased by enlistments from the militia, but there is great unwillingness to save the country unless in a constitutional way. . . . Our country gentlemen make no distinction in the means of defence they would adopt between an insignificant rebellion in Scotland and the mighty invasion with which we are now threatened. . . . We have nothing very

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great to expect till the enemy is actually amongst us. He will then give us a practical lesson."*

Nothing awakened John Bull. He jogged along in the old ruts. Successive Cabinets sought to co-ordinate the regular army, militia, and volunteers. Pitt, Dundas, and Windham; Addington and Hobart; Pitt, Camden, and Castlereagh; Grenville and Windham successively produced their reforms until chaos reigned supreme. The Perceval Ministry (1809–12) totally failed to solve these difficulties, which, of course, could be overcome only by the adoption of conscription; but that nervous Cabinet feared to take so drastic a step. After the disastrous failure at Walcheren it hesitated to send Wellington the needful supplies either in men or money; and (as will appear later) so unpopular was the Peninsular War that the Whigs, who opposed it outright, might well have ejected Perceval if he had greatly increased the taxes. Home politics, therefore, prevented a vigorous prosecution of the war, until, in the summer of 1812, the action of Russia breathed new energy into the calculating trimmers of Westminster. Harsh things have been said by soldiers of politicians during this war, but nothing comparable to the insults hurled by Napier at the memory of Perceval: "The politician, believing in no difficulties because he feels none, neglects the supplies, charges disaster on the general, and covers his misdeeds with words."†

But the damning charge against the Portland and Perceval Cabinets is their ineffective use of the existing forces. In 1808–9 the effectives were 26,500 cavalry, 178,000 infantry, artillery and engineers, 24,000; and the embodied militia, 77,000. Pasley in 1811 reckoned that, by calling up the reserve militia and training the volunteers, 120,000 men might be spared for active service. He arraigned British statesmen of timidity and blindness in keeping so many regulars at home, and in frittering others away in spasmodic and generally belated efforts. Our troops (he wrote) cost half as much again as those of any other nation; our politicians rarely looked ahead, never framed a consistent military policy, or provided adequate equipment. If they continued to act thus we should "have nothing before us but the gloomy prospect of eternal war." We must act on land as vigorously as by sea, or else we might be conquered on both elements. Trust in Coalitions was futile; indeed, in course of time—"*Germany might become so powerful as to act the part which France now does.*" Let us vigorously support Wellington and the Spaniards, for there only could we hope to overthrow Napoleon's power.

* *The Paget Papers*, II., p. 316.

† Professor Oman (*Peninsular War*, IV., p. 67) rebuts the diatribes of Napier against Perceval (Napier, bk. xi., ch. 10, xiv., ch. 2); but, surely, after Torres Verdas, Perceval should have properly supported Wellington or resigned if Parliament refused.

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Such is the gist of Pasley's essay, which I recommend as a tonic to the croakers of to-day.*

Wellington, also, in the spring of 1812, asserted that Napoleon's ascendancy was rotten at the base, being "sustained by fraud, bad faith, and immeasurable extortion"; and that an honest understanding among the European Powers would end it.† If in those dark times our military thinkers foresaw the issue of 1814–15, have we any cause for pessimism now, when all the Powers of the world are united for the overthrow of a supremacy which is less intelligent and inspiring, far more odious and extortionate? May we not also derive confidence from a survey of our recent military efforts which dwarf everything that Pasley deemed possible? In efficiency the British Army probably excels our Peninsular Army which in December, 1812, Wellington pronounced inferior to a French army presumably of equal size.‡ The levies of 1914–16 are certainly equal to the highly trained German Army—a feat of organization which dwarfs every other effort in our annals.

Relatively to Germany, it seems probable that we occupy a position more favourable in naval affairs than our forefathers did to Napoleon in 1810–12. At that time and down to the spring of 1812 he excluded us from intercourse with the Continent, except Turkey and parts of the Spanish Peninsula. His empire comprised nearly all the coastline from Hamburg to Venice and Ragusa; he had the active support of the Danes, and in June, 1812, when Russia failed him, the United States declared war against Great Britain. Potentially, therefore, his resources in shipbuilding were far greater than ours, and he hoped to overwhelm us at sea. Thus, on March 8th and August 9th, 1811, he bade Decrès, Minister of Marine, prepare for great naval enterprises in 1812; eight sail of the line must be ready at the Texel, twenty at Antwerp or Flushing, and large squadrons in French and Italian ports, for expeditions to Ireland, Sicily, Egypt, Martinique, Surinam, "*et tout le Continent hollandais*" (Australia). Pinnaces were to be built suited to the navigation of the Nile and the Surinam. The Boulogne flotilla must be prepared to carry 30,000 infantry, 6,000 cavalry, and 2,000 artillerymen. In the spring of 1812 fears of invasion revived in England. On January 23rd, 1813 (that is, even after his disaster in Russia), he ordered naval construction which would raise the numbers of his battleships to 104. At that time we had only 102 in commission, with 22 in reserve; and in view of the hostilities with the United States, the horizon was not reassuring. True, we had reduced the last of the enemy colonies, Java, and we controlled the tropics; but the immense extent of the Napoleonic coastline required that at least five

* Pasley, *op. cit.*, pp. 19, 40, 98, 105, 119, 146, 498—501.
† *Life of Sir W. Gomm*, p. 240.
‡ Croker's *Diaries*, I., p. 41.

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British squadrons should blockade or observe his chief ports, and he hoped thus to wear us out until his new fleets could challenge us to decisive combat.

In guerilla tactics at sea he had many advantages. It was impossible to prevent hostile cruisers from slipping out and doing mischief. In 1811 the French and their naval Allies captured seven, and in 1812 eight, British cruisers, while we took or destroyed seven and four respectively. Our losses by wreckage were always far heavier (*e.g.*, three sail of the line and 15 cruisers, as against one French cruiser in 1811). In that year not one hostile squadron evaded our blockading forces, though the Toulon fleet attempted a futile sortie. But Napoleon continued to press on naval construction, and Pasley deemed the scattered British possessions so vulnerable as to make the issue doubtful against the dominating mass of the Napoleonic System. Strategically, it possessed enormous advantages over the present German Empire, which in open waters can act only from "the wet triangle" (the Ems, Heligoland, the Elbe) and from the Flemish coast. The further his System extended, the heavier were the losses to our merchant shipping, viz., 387 in 1804 to 619 in 1810. Thus, Trafalgar procured no immunity for our mercantile marine, which in 1810–12 was at the mercy of cruisers and privateers from nearly all the ports between Copenhagen and Venice.

On one topic the Napoleonic and the German strategy lays equally insistent stress, viz., the supreme importance of possessing the Flemish coast. "He who holds Antwerp," said Napoleon, "holds a loaded pistol at the head of England." During the futile negotiations at Châtillon in March, 1814 (*i.e.*, when he had virtually lost Holland), he said: "I am ready to renounce all the French colonies if I can thereby keep the mouth of the Scheldt for France." That dominating point, then, was worth the former colonial Empire of France, obviously because from Antwerp to Ostend he could coerce England at his will. Such, too, is the creed of Berlin; and by their submarine and aerial warfare, waged largely from Belgian bases, the Germans have, with their usual fatuity, supplied novel and irresistibly cogent arguments for ejecting them thence.

The crowning contrast between 1811–12 and 1917–8 has already been hinted at. Perceval's unwise maritime procedure led to the American declaration of war in June, 1812, and to a serious diversion of British naval and military strength. The signal tact and moderation of the British Foreign Office and Admiralty in 1914–7 paved the way for friendly relations with our kinsmen; and under the pressure of German frightfulness these developed into an alliance which may prove to be one of the decisive issues of the War.

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TRANSCRIPT.

IS IT NOT TREASON TO CRY DOWN THE HORSE?

From the "Rider and Driver," U.S.A.

If it be treasonable to do anything by word or deed that impairs our military efficiency with regard to, say, shipbuilding, motor manufacturing, railroad transportation, and other vital activities, why is it not equally infamous to howl down the horse? It is an incontrovertible fact that even in this latest and most scientific of wars, the horse is more necessary than ever before, and that the supply, rapidly diminishing, has been largely reduced as much by the effects of a malignant propaganda as by the economic exigencies that lessen demand. In late years the cries of "down with the horse," "horseless age," "passing of the horse," and similar objurgation, have been heard throughout the land while, at the same time, the contending nations have been scouring the earth for horses, their requirements being estimated to be one horse to every three men in the service of arms. Competition in business affecting the horses' sphere is commendable and the "life of trade"; but, when such selfish considerations materialize into a form of persecution that is detrimental to the best interests of the national weal, it is time to call a halt. Instead of such drastic methods as have been used to displace the horse a spirit of "live and let live" should prevail, at least so far as the commercial phase of the situation is concerned; but when that kind of business promulgation reaches the point of endangering the lives of our heroes at the battle front the nobler impulse of patriotism must be rallied to inspire reactionary sentiment. We are not merely expressing sentimental wishes, but stating facts as to the critical importance of the horse. It is irrefutable, for example, that three months before Germany participated war, that country had purchased 350,000 horses from France alone, thus proving that the most militant power of the world, foreseeing, appreciated the inestimable advantage of the animal. This number was only a drop in the bucket, so to speak, compared to the thousands upon thousands of horses bred in Germany and Austria-Hungary, and bred for many years, with an especial view to their value for campaign purposes. From England, too, Germany had purchased the best stallions for breeding available, without regard to price, paying as high as $125,000 for a single horse, the famous Ard Patrick, which so far as we know, is still in the enemy stud. The losses of horses by the Central Allies have nevertheless, been stupendous and it is believed that they have not been replaced by at least 50 per cent. In the final shocks of the fray this will tell against

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the enemy tremendously although, we believe, their cavalry have been maintained in the background at the fullest strength, awaiting mobile action when the trenches have been abandoned. In view of these circumstances and especially in response to the call from General Pershing for more horses and more horses, as they say of ships, and for more cavalry, and more cavalry, the Secretary for War has instituted a tardy but strenuous drive to fulfil the obligations imposed and which in better prepared countries were never overlooked nor undervalued. Whole volumes have been printed on the deeds of the horse, but it is not necessary to revert to them as they are known to every intelligent reader of history. As much, if not more could also be written of the horse's incalculable services in the present struggle. It should suffice now for everybody who loves his fellow man, and who is sacrificing affection and fortune for the cause, to realize the stupendous significance of the horse in this titanic struggle for the freedom of the universe. It sounds hackneyed and inadequate to quote Richard III.'s desperate appeal, " A horse ! A horse ! My kingdom for a horse ! " but never was there a time when the immortal phrase applied with such sonorous open diapason as at this moment, when kingdoms tremble, to fall at the approach of whichever may be the mightier hosts' thunderous vibration of horses' hoofs. " Long live the horse ; man's best friend in war as in times of peace ! "

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REVIEWS.

PAGES D'HISTOIRE, 1914—1917.

(Published by the Librairie Militaire Berger-Levrault, 5—7, Rue des Beaux Arts, Paris).

(*Continued from R.E. Journal for May*, 1918).

The 146th and 147th numbers of the above series contain the Official Communiqués issued by the Central Government to the Provincial Authorities of France; they are the XXXIII. and XXXIV. volumes respectively which deal with this subject.

The 146th number relates to the events of August 1917 and contains appendices giving (*a*) the text (in French) of the telegram sent, on 3rd August, 1917, the date of the third Anniversary of the declaration of War, by H.M. the King to the President of the French Republic; (*b*) the text of the telegram from the latter to King George acknowledging H.M.'s message; (*c*) the text of the telegram sent by President Poincaré to the King of Italy after the former's visit to the Italian front in August, 1917; (*d*) the text of the telegram from King Victor Emmanuel to the French President acknowledging the latter's message; (*e*) the text of the telegram sent by the French President to the King of Italy congratulating him on the then recent successes of the Italian troops; (*f*) the text of the telegram from King Victor Emmanuel to President Poincaré acknowledging his message; and (*g*) the text of the speech made by the French President on the occasion of his visit to Verdun, on the 29th August, 1917, at the ceremonial in connection with the investiture of General Pétain with the Grand Croix of the Légion d'honneur.

The ceremonial in question took place in the public square of the historic town; the investiture having been carried out with the customary formalities, President Poincaré addressed the gallant defender of France's much renowned fortress in the following terms:—

"The Premier and the Minister for War have, in the letters sent you conveying the congratulations of the Government of the Republic, expressed to you in heartfelt terms the latter's deep confidence in the army and the sense of gratitude of the whole country. In investing you to-day, in the presence of a part of your valiant troops, with the Grand Croix which has been awarded you, it gives me much pleasure to inform you personally, how proud France is of your success and what reliance she places in you, in the Generals, officers and incomparable men serving under your command.

Since the day on which the task was assigned to you to secure our military position at Verdun for us, the eyes of the whole world have been turned towards this glorious city and the zone of Lorraine territory

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adjacent thereto and surrounding its ancient walls which are now rent by many an enemy shell. The entire human race has appreciated the fact that in the gigantic and tragic struggle taking place here, on the two banks of the Meuse, was being settled the question of the liberty of peoples and the future of civilization.

This ravaged countryside, through which I have often journeyed in your company—this despoiled territory which has acquired a symbolic significance and no longer remains the outlying feature alone of a celebrated stronghold, but is to-day the glacis itself of an ideal citadel wherein Right itself is entrenched; this soil made illustrious by so many a combat, sanctified by so much blood that has flowed—has the French Army defended step by step and reconquered stretch by stretch; and here to-day, under your supreme command and under the direction of tried chiefs, it has retaken by assault, after a skilful artillery preparation, the heights, so often disputed, whence the enemy was commanding our positions, watching our movements, and controlling the fire of his own batteries. A striking victory now answers, as a resounding echo, to the successes obtained day by day by our troops on the Chemin des Dames; to the brilliant advantages secured by our troops on the plains of Belgium; to the heroic fights, put up in Flanders by British troops; to the important progress made by the Italians on the rugged slopes of the Monte Santo and on the rocky plateaus of the Carso.

In these combined operations on an extensive scale the French Army has put forth, as has ever been the case, its full share of effort. Never in its history has it shown a higher courage, a loftier spirit. Three years of violent fighting have neither worn out its strength, nor cooled its ardour. In this long trial it has been invigorated by knowledge of the fact that the safety of its native land was at stake and by the will to fight on until a triumphant peace could be assured.

In vain our enemies have been trying to spoil history and to disseminate fairy tales in neutral countries. In vain do they make desperate efforts in order to throw off the responsibilities that are weighing them down. In vain are the factories for the manufacture of lying information, located in the cities of the Central Empires, giving off clouds of black smoke without ceasing, clouds which a propitious wind is ever blowing across their frontiers, clouds that continue to evaporate into thin air as soon as they reach the boundaries of the zone of truth.

Convinced, at last, that she can no longer hope for a military victory on our front, Germany has taken refuge in a final illusion; she thinks that she has got the better of us owing to the internal crises of our country and, for weeks past, she has been noisily airing her views on the subject. Neither these puerile manœuvres, nor the infamous propaganda that accompany them—a propaganda which the judiciary will repress with a strong hand—whenever they have attempted to gain a footing in our midst, have succeeded in disturbing the public spirit of our people which continues to remain worthy of our cause and the splendid soldiers who are defending it.

Entire France is at war; no part of it will allow itself to be stampeded.

Confident in the magnificent army which you are commanding in so

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masterly a manner, wherefrom it has received a new stimulus for hope; confident in the loyalty, in the energy, in the growing strength of its allies, France conveys to you to-day, to your officers and to your men, its congratulations and makes known its vows; it repeats its former assurances: 'Depend upon me as I depend upon you and your men. Together, we will fight on until final victory is ours. Together, we will work to establish, on the firmest of firm foundations, the reign of a propitious Peace and the Sovereignty of Right.'"

Subsequent to the foregoing ceremony the French President, accompanied by the War Minister, and Generals Petain and Guillaumat, visited the Headquarters of the 2nd (French) Army to congratulate the staff on their brilliant success. Some of the Divisions which had taken part in the recent operations were next reviewed.

In the afternoon of the same day, President Poincaré went over a part of the ground reconquered on the two banks of the Meuse, he inspected the troops in the locality and warmly congratulated General Guillaumat, his officers and men.

The 147th number contains in its appendices: (*a*) the text of a telegram from King Ferdinand to the French President on the occasion of the second Anniversary of Roumania's entrance into the War; (*b*) the text of President Poincaré's reply to H.M.; (*c*) the text of the telegram from the Belgian King to the French President after H.M.'s visit to the French Front; (*d*) the text of President Poincaré's reply to King Albert's message; and (*e*) the text (in French) of President Wilson's reply to the Pope's manifesto of the 1st August, 1917, to the belligerent nations.

In his reply to His Holiness Benedict XV., President Wilson stated that no one who was not blind, or whose heart had not been turned to adamant by this War, could have failed to have been touched by the moving appeal of the present occupant of St. Peter's chair, to have felt the dignity and the force of the humane and generous motives that impelled the Sovereign Pontiff to make an attempt to direct the belligerents on to the paths of peace. But, at the same time, the President of the Great American Republic pointed out that it would indeed be fatuous and foolish for any belligerent Power to follow the indications on the guide-post, which His Holiness had put up, if the way indicated, in reality, did not lead to the destination all were seeking.

Clearly, it was not a mere armistice that the Pope was desirous of bringing about, but a permanent and stable peace.

Reviewing the Pontiff's proposals, President Wilson pointed out that what, in substance, the belligerents were required to do was to return to the *statu quo ante bellum*, on the understanding that no reparation should be demanded in respect of injuries suffered, but that a general disarmament should ensue on the basis of the creation of a Concert of Nations, which should rely on the principal of arbitration for the settlement of future disputes and differences; that the liberty of the seas should be secured by a similar international concert; that the territorial claims of France and Italy; the complicated problems of the Balkans and the restoration of Poland should be settled by mutual agreement on bases which would remove all causes of future discord.

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In the opinion of the American President no part of the foregoing programme could secure results worth having if the return to the *statu quo* could not be secured on a firm and satisfactory foundation. The main object of the present Conflict was to deliver free peoples of the Universe from the thraldom of a vast military organization, subject only to the dictates of an irresponsible government, which, having secretly laid its plans for the domination of the habitable globe, had put into execution its projects without paying the least respect to Germany's sacred treaty obligations or to the long established customs and recognized principles governing international relations and the code of ethics of civilized peoples; a government, which had chosen its own appropriate hour to force on a war; one which had struck its first blow not only suddenly, but with an excess of brutality; one which had not considered any law or any feeling of pity a hindrance to the most dastardly of acts; one which had submerged a whole continent under a tide of blood, not that of soldiers only, but also that of women and innocent babes and of poor defenceless mortals; and one which was standing in arrogant defiance that day, brought to halt no doubt, but not yet subdued; a government that was the enemy of four-fifths of the population of this world.

It was not, said President Wilson, from the German people that this power sprang, but from their pitiless masters. It was not for the belligerents to seek the why and the wherefore of the subjection of a formerly great people to the domination of a military clique; but it was their affair to see to it that the History of the remainder of the world should not be written by German hands.

His Holiness was next informed that the only effect likely to follow from the acceptance of his proposals would be to allow Germany to recuperate her strength and to permit her to continue the policy which had brought so much disaster to the world. To combat such a situation, it would become necessary to form a permanent coalition of nations hostile to the German people; Russia would have to be abandoned to be a prey to new intrigues.

President Wilson pointed out also that well-informed statesmen must now see, if they did not do so prior to the outbreak of the War, that the permanence and durability of peace was not something to be attained by political or economic restrictions imposed with the object of favouring certain nations at the expense of others. The American people had, it was stated in the reply, suffered much at the hands of the Germanic Imperial Government, but it did not intend to pursue a policy of reprisals against the German people. The American people held it as a cardinal article of their political faith that peace must rest on the foundation consisting of the Rights of people and not those of governments, on the former's equal Right of liberty, on the former's Right to determine their own forms of government and to participate, on equitable principles, in full measure in all things connected with the economic activities in the world of industry and commerce. The real criterion of a satisfactory peace was that it should be founded on the reciprocal faith of the peoples interested; it could not be secured by a contract based on the word of an ambitious and intriguing Government of the one part and on the

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promise of a group of free peoples of the other. The aims of the United States in this War were, said President Wilson, known to the world at large, to all who seek the truth. America was not seeking material advantages of any kind. She demanded that reparation should be made for the disastrous mischief worked by the brutal and infuriated power of the Germanic Imperial Government, but not that this should be secured at the expense or to the detriment of the sovereignty of another people. On the contrary, America claimed the rights of sovereignty on behalf of the weak as well as of the strong; she considered punishments of a penal order, the dismemberment of Empires, the creation of egoistical and economic leagues to be out of place and to represent a most unsuitable coinage in which to measure the damages in the cause. The true foundation of the peace America is seeking must be built up on the principles of justice and equity, on the common rights of humanity.

In conclusion President Wilson made it known that America was not prepared to accept the word of those then responsible for the government of Germany as providing the necessary guarantee on the faith of which the American people could conclude a solemn contract with the German people. Before proceeding further it was necessary, he said, for the Central Powers to provide some new and acceptable proof of their good faith and of the abandonment by them of the principles that have brought so dire a catastrophe into the world as that witnessed in the autumn of 1914.

W. A. J. O'MEARA.

THE YEAR-BOOK OF WIRELESS TELEGRAPHY AND TELEPHONY, 1918.

The sixth Annual number of *The Year-Book of Wireless Telegraphy and Telephony* has duly made its appearance. The volume continues to grow in size; but, needless to say, its quality remains at its previous high standard. *The Wireless Press Ltd.* (Marconi House, W.C.) is indeed to be congratulated on having produced so complete a guide-book on Wireless Telegraphy under the extremely difficult circumstances that prevail to-day. Owing to the general rise in cost of labour and of materials the price of the volume has been raised to 6s. net.

The volume is provided with a large number of photographic reproductions. These illustrations include several pieces of apparatus used by the late Mr. W. Duddell, F.R.S., in his investigations and in connection with his discoveries. Other illustrations relate to the most recent types of wireless instruments, and to views of wireless stations; portraits of some of the leading men in the radiotelegraphic world also appear in the volume.

"The Record of the Development of Wireless Telegraphy and Telephony," provided as an introduction, is brought down to the end of 1917. Among the more important items entered under the year 1917 are a reference to the "Coming of Age" of wireless telegraphy on the

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2nd June, 1917; to the considerable developments which have taken place in connection with the utilization of wireless for military and naval purposes, and more particularly in relation to its use in connection with aircraft; to the amended regulations relating to compulsory wireless for sea-going vessels, whereby the former tonnage limit of 3,000 tons has now been brought down to 1,600 tons gross; to the wireless developments in Australasia and the Pacific; to the purging of Africa from enemy wireless influence; and to the suspension of Transatlantic Commercial Wireless Service in August last by direction of the British Government.

There is no change in the matter comprised in the section entitled "National and International Wireless and Regulations." On the other hand, in the section dealing with the various acts, decrees, regulations, etc., in force in the several countries of the world much additional matter has been included; not only do the laws and regulations of some countries appear therein for the first time since the issue of the *Year-Book*, but a useful introduction has been added to the information hitherto furnished in this section: the geographical limits of the several countries, and in some cases a few important historical facts, a reference to the constitution or fundamental law of the country, the organization of the radiotelegraphic service and matters of administrative importance, have also been included.

An increase has taken place in the numbers of both the Land Stations and of the Ship Stations, but owing to the fact that full particulars have not been published, for obvious reasons, in relation to many of these stations it is not possible to say whether the number of long-distance stations have been increased or not. The information given under the heading of Ship Stations bears the impress of war; the compulsory transfer of ownership of many vessels, involving a change of flag, is to be found recorded in the pages of the volume under review. The Land Stations occupy 64 pages (as compared with 62 pages last year), whilst the Ship Stations occupy 153 pages (as compared with 141 pages last year).

The articles on scientific and other subjects, which have formed a special feature of the *Year-Book* since its first publication, are continued. The first of them, by Dr. J. A. Fleming, F.R.S., is entitled "Waves in Water, Air, Earth and Æther." Dealing first with sea waves, Dr. Fleming reminds us that the nature of the movement of a travelling wave as it appears to the unpractised eye is not its real one; floating matter on the surface of sea waves does not actually advance continuously forward, but really describes a wide or closed curve with its plane in the direction in which the waves appear to travel; that is to say, wave motion is in fact a periodic or cyclical motion of some kind wherein the several points of a medium move successfully and not simultaneously.

Wave motion depends upon the power of various kinds of continuous media to store up energy in two forms viz.:—(*a*) the potential form and (*b*) the kinetic form. In the case of the water surface wave, at each point of this surface, the total energy changes its form cyclically and passes by degrees from potential to kinetic and back again.

The number of complete changes per second at any one point is called

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the *frequency*, and the following rule holds universally for all kinds of wave :—*wave velocity=wave frequency* × *wave length.*

In the case of water surface waves (on deep water) the wave velocity varies as the square root of the wave length.

The speed (in miles per hour) of deep sea waves equals the square root of $2\frac{1}{4}$ times the wave length (in feet).

Such waves are called gravitation waves, since the rise and fall of the water is determined by the force causing it to fall towards the centre of the earth.

There is another class of surface water waves which owe their origin to the fact that the surface of the water resists stretching ; they are known as capillary waves or ripples and possess the peculiarity that their velocity is *less* the greater the wave length, being in this respect the opposite of deep sea waves.

Quite another kind of wave motion is capable of propagation in media possessing compressional elasticity : such waves consist of alternate regions of compression and expansion and are termed acoustical waves.

The velocity of acoustic waves in water has been ascertained to be 4,707 ft. per second at ordinary temperatures. Similar acoustic waves can be formed in air and are caused by a to-and-fro motion of air particles in the direction of propagation of the waves, giving rise to alternate regions of condensation and rarefaction. The amplitude of each individual particle is very small—in the case of the least audible sound of a whistle in air not more than one-twentieth part of a millionth of an inch.

The velocity of an acoustic wave is air is 1,090 ft. at 0° C. Only the acoustic type of wave can be produced in a gas, but in solid bodies, such as the earth, owing to the different kinds of elasticity present therein, other types of waves are also possible ; they are known as the compressional and the distortional waves—the earthquakes waves being an example thereof.

In the case of seismic disturbances, some waves, probably the compressional, travel with a velocity of about 10 kilometres per second ; whilst other waves, probably the distortional, travel with a less velocity of 5 kilometres or so per second.

The general law which determines the velocity of a wave is that the velocity is directly proportional to the square root of the elasticity and inversely as the square root of the density.

Reckoning in pounds and feet, and using absolute units of force, Young's Modulus of Elasticity for steel is represented by 134,000 million and since the absolute density of steel is 550 lb. per cubic foot, by the above rule, the velocity of sound in steel is 15,500 ft. per second, *i.e.* approximately 3 miles per sec. Therefore if a steel wire could be stretched from the earth to the moon (240,000 miles distant), a wave impulse started on the wire at the earth at a given moment would not reach the moon till 22 hours later. In the case of such a wire stretched between the earth and the sun a wave impulse started thereon at the earth would take nearly a twelvemonth to reach the sun.

There are as a matter of fact as many types of waves as there are kinds of elasticity. The velocities of the different types of waves along the same materials naturally differ.

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For further information on wave velocity the reader is referred to Dr. Fleming's article in the *Proceedings of the Physical Society of London* (Vol. 29, Part III., April 15th, 1917).

The subject of waves in the imponderable and impalpable medium called the æther is next considered. The arguments which lend support to the view that such an ultramaterial substance exists are briefly stated. We are compelled to postulate such a special medium in order to account for phenomena perceptible to our senses, but, from the material point, all we know about the æther amounts to this:—it is not gravitative matter, but something of a superior nature. Investigations made so far have provided no evidence that this universal æther is capable of motion in its parts relative to each other, nor can it be said that it possesses mass in the sense that motion of any part represents kinetic energy associated with the moving portion.

Clerk Maxwell's remarkable contribution to our mathematical knowledge on the subject is touched upon and the experimental confirmations by Lebedew, Nichols, Hull and Poynting of the existence of Maxwell's light-pressure and the correctness of the value thereof predicted by his theory are referred to.

Hertz's work in connection with the creation of Maxwell's electro-magnetic waves of long length by means of electric oscillations in open circuits naturally comes in for mention. Further, the work done by Bose, Righi and others whereby electro-magnetic-waves have been shortened—so that they can be obtained of a length not exceeding 0.6 millimetre—is also noticed.

Finally, Dr. Fleming points out that it is possible by certain methods to isolate from sources of heat and light very long heat waves—the Rest-strahlen or residual rays. The wave length of the longest waves so isolated is about 0.006 centimetre. Thus between the longest heat waves emitted by incandescent bodies and the shortest Hertzian waves emitted by oscillators there is a gap or difference of 0.006 to 0.6 cm.—or 1 to 1,000, *i.e.*, nearly 9 octaves.

In spite of the discoveries to date, it must not be assumed that our theories of light or of æther are impregnable; on the contrary, it is necessary to continue our researches in order to formulate some broader and more complete theory of light, so that all the known optical and electrical facts may be embraced thereby.

The second article is entitled "Heroism" and contains a reference to some recent examples of devotion to duty displayed by ship's telegraphists, the portraits of some of whom are included in the volume. The names of the young heroes and a short account of their exploits are duly recorded. The author of the original article points out that Britain's fighting services and her commercial organizations are going forward hand in hand, "marching towards the same goal, animated by the same spirit, and manned by scions of the same indomitable stock." The people of this country have indeed every reason to be proud of every class of its sea-faring population; no signs of decadence have made their appearance in that quarter.

The third article is entitled "On the Energy Transmission in Wireless Telegraphy" and has been contributed by Mr. B. Van-der-Pol (Jun.),

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Doct.Sc. (Utrecht). The author of the original article points out that the mathematical difficulties in calculating the electric and magnetic forces in the space round a sending antenna are of a very different order from those to be overcome in designing the closed sending and receiving circuits of a wireless station. When the wave-lengths used are great in comparison with the dimensions of the antenna and the other circuits of the station the element of time is the only independent variable entering into the differential equations determining the currents and potential differences, so that the integral solutions of these equations give the currents and P.D. as dependent upon the time only.

On the other hand, in the case of the determination of the electric and magnetic forces set up in the alternating field round a sending antenna terms will occur in the differential equation depending both upon the time as well as upon the co-ordinates of space, thereby adding considerably to the difficulty of solution of the differential equations.

It is for this reason that, during the past ten years, experiments in wireless telegraphy have gone far beyond the theoretical investigations, which cannot yet interpret in a mathematical way the experimental results obtained. And yet, in wireless telegraphy, theory anticipated the experiments performed a quarter of a century later.

All the theories concerning the transmission of energy as used in wireless telegraphy represent so many solutions of one single differential equation, the so-called wave-equation which must be satisfied both by the electric and by the magnetic forces in the space round the sending-antenna.

The wave-equation is given in the original article and Mr. Van-der-Pol reminds us that the first solution thereof of real value for radiotelegraphy was that given by Hertz in 1888; it still forms the principal foundation of most of the transmission theories. Hertz proceeded on the assumption that he had to deal with a doublet vibrating freely in the ether, so that the waves produced by it travelled undisturbed in all directions in space. He found that the electric force in the equatorial plane—*i.e.*, the plane cutting the axis of the doublet perpendicularly—is everywhere at right angles to it. The decay of this force as it travels outwards takes place in an inverse geometrical ratio; at small distances from the doublet the electric force varies as r^{-3}, at greater distances it varies as r^{-2} and ultimately it varies as r^{-1}. It is this law of the inverse first power for a *vibrating* doublet which, together with the effect of oscillations of accumulating energy in a tuned receiver, made wireless telegraphy over great distances possible with comparative low power.

A graph is given in the original article which clearly shows the very rapid decrease in the received current intensity near the oscillator and the much lower rate of falling off at greater distances.

Since in practice the antenna is usually near the earth's surface a modification of the theory for the electric doublet free in space is necessary for the purpose of explaining the circumstances found in actual wireless transmissions, *i.e.*, when the Hertzian dipol is placed on an infinitely extended plane of an ideally low resistance, this plane representing the earth. The condition to be fulfilled by the electric force

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in such an infinitely conducting plane is that it shall be normal to that surface everywhere. As a matter of fact, the conducting surface of the earth takes the place of the equator-plane in the case of the idealized Hertzian oscillator and, in consequence, the distribution of the electric force is not altered. In the case, therefore of the doublet (representing the sending antenna) placed at a conducting surface (representing the earth assumed plane) the electric force will follow the law stated above.

The simple doublet theory is naturally not applicable to every form of antenna so far as the space very near thereto is concerned, but, at distances exceeding a couple of wave lengths, the theoretical energy distribution found round a vibrating doublet represents sufficiently nearly the electric conditions set up by a wireless telegraph antenna.

The author of the original article refers to the theory, developed by Zenneck, based on the assumption that the earth has a finite conductivity, together with a dielectric constant differing from unity; a theory which is full explained by Dr. Fleming in his work *Principles of Electric Wave Telegraphy*, wherein he shows how great numerically is the influence of the wave-length and the electric nature of the earth's surface for certain transmissions.

In 1909, Sommerfeld propounded a theory which was a combination of the theory of Hertz and that of Zenneck; therein the divergence of the waves from a station in all directions, *together with* the finite conductivity of the earth were both taken into account.

In Sommerfeld's theory the sending aerial is mathematically represented by a dipol oscillator as in the Hertzian theory, but it is assumed to be placed at the boundary surface between the air and the earth's surface. The amplitude of the waves found in this way is given by a definite integral involving a cylinder function of zero order. An artifice, consisting in a certain numerical quantity called the " numerical distance," has to be introduced to render the solution of the function possible.

The author of the original article has computed the approximate values of the " numerical distance," as a function of the distance, for different wave-lengths and conditions of the earth's surface; the results of some of his calculations are included in the text of the original article.

In the case where the " numerical distance " is a large quantity the total electromagnetic field—which is somewhat complicated—can be represented mathematically as being composed of two constituents, (*a*) a space wave and (*b*) a surface wave.

In the case where the " numerical distance " is a small quantity, the Hertzian theory of ordinary space waves may be applied with a fair degree of approximation; it is found that, under these circumstances, the value of the wave amplitude will be very near the value calculated on the assumption of a perfectly conducting earth.

The author of the original article points out that the mathematical abstraction called a surface wave will, in general, dominate the accompanying space wave at distances from the sending station whereat the electrical constants of the earth and the wave length used together determine a " numerical distance " of quite moderate value. A table

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is given in the original article showing the limits within which the real distance must lie—corresponding to the different wave-lengths and materials—in order that the surface wave contribution to the total electro-magnetic disturbance may be regarded as of importance in comparison with the space wave.

It is further stated that " the way in which the sending antenna is earthed can have no direct influence on the production of surface waves. Their development cannot be assisted by the use of a direct earth or a balancing capacity, but is wholly determined by the ' numerical distance.' ".

A later mathematical investigation by Sommerfeld indicates that, given a suitable combination of a comparatively high dielectric constant and a fairly low conductivity, even a larger amplitude than would be obtained in the case of an infinitely good conducting earth surface should be secured for certain wave-lengths at short distances ; *e.g.*, for waves of 2,000 metres length travelling over fresh water a greater amplitude can be expected at distances up to 100 km. than a perfectly conducting earth would allow.

The author of the original states that so far as he is aware this very unexpected result has never been explained in a physical way. He suggests that the favourable effect of a material like fresh water with a high dielectric constant but of low conductivity may be due not to a better *transmission* of the waves than in the case of a perfectly conducting earth, but to a better *emission* of electro-magnetic energy.

Mention is made of the fact that the problem of the bending of electric waves round the curved surface of the earth has been attacked by several mathematicians, among whom are numbered Macdonald, Poincaré, Nicholson, March, von Rybczinski and Love.

A brief description of the problem and the methods of attack thereon are given in the original article, which should certainly be consulted by all who are interested in the theory of wireless telegraphy.

Graphs are published with the text of the original article ; these graphs show the results obtained by various workers ; that these results do not agree is not to be wondered at when the complicated nature of the problem dealt with is considered.

In the theories considered by the eminent mathematicians in question the earth has been treated as a sphere consisting of an infinitely good conducting material. But a closer approximation to the circumstances as found in actual practice of wireless telegraphy has been obtained by solving the same problem for a sphere of finite conductivity.

The author of the original article refers to the experiments made by him with a view to the determination of the conductivity of sea-water in relation to high-frequency alternating currents. He has arrived at the conclusion that down to wave-lengths of 600 metres the conductivity of sea-water does not vary with the frequency.

Attention is called to the fact that the measurements of received antenna currents at different wave-lengths and distances by Austin, Hogan and others show discrepancies in relation to the values which should, on the basis of the theories discussed in the original article, be obtained ; it is for this reason that a consideration of the reflective and

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refractive action of the ionised higher layers of the atmosphere has been introduced into their investigations by some workers in this field.

In conclusion, Mr. Van-der-Pol points out that, in order to eliminate the still apparent discrepancy between the electro-magnetic theory of the bending of the waves round the earth's surface, based on the Maxwellian equations, and the actually measured values of received currents, first, an agreement on the theory of the subject has to be reached so that further investigations may all proceed on the same foundation, and, secondly, very careful measurements, on a more extensive scale than carried out hitherto, are necessary.

The fourth article is entitled " Wireless Telegraphy in the U.S.A." and has been contributed by Mr. David Sarnoff, Secretary, Institute of Radio Engineers, who points out that " while a declaration of war naturally affects, in a material way, the industries of a nation, yet it is questionable whether any enterprise in the United States has undergone so complete a change as wireless in so brief a period with less friction, lost motion, waste, uneconomical production, and many other evils which attend a hasty transformation."

The satisfactory results that have been obtained have been due, it is recognized, in a large measure to the wisdom, fairness, and efficiency of those who administer the affairs of the United States Government. The capabilities of the officers directly charged with responsibilities connected with the provision of wireless equipment and for the maintenance of wireless communication is distinctly high and the manner in which they are carrying out their duties has produced a feeling of confidence in the minds of those who have dealings with them.

The pressing needs of the hour, it is pointed out, were : " To provide facilities for the manufacture of the radio equipment for the large number of vessels built and commandeered by the Unites States Shipping Board and the United States Navy Department ; a constant supply of licensed wireless operators for service on the rapidly increasing merchant marine ; trained men to instal the radio apparatus on the vessels, and engineers capable of coping with the many problems of wireless communication and production."

The response of the wireless companies and their *personnel* has been " in tune " with the requirements and everything has been done to meet and satisfy the needs of the Army, the Navy and the Shipping Board programmes.

" The effect of the war, on the wireless art in the United States has," Mr. Sarnoff states, " been a rapid development and expansion of a comparatively limited industry to one of considerable magnitude."

The fifth article is entitled " The Magnetic Behaviour of Iron in Alternating Fields of Radio Frequency " and is from the pen of Dr. N. W. McLachlan. In an introductory paragraph, we are reminded that it has long been known that iron is influenced by the oscillatory discharge of a condenser ; the discovery of this fact was made in 1842 by Professor Joseph Henry. Much experimental work has been carried out, in recent years, on the magnetic behaviour of iron and other magnetic substances, *e.g.*, nickel. It is now fully recognized that iron responds to high-frequency magnetization produced by damped or

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undamped oscillations ; experiments also prove that it undergoes cyclic changes and retains its magnetic properties even at frequencies of several millions per second.

The subject is dealt with in the article under review under the following heads :—The propagation of magnetization in iron ; the behaviour of iron under alternating magnetization ; hysteresis and eddy current losses ; variation in permeability with temperature ; the use of iron in high-frequency apparatus ; and the efficiency of using iron at H.F. compared with that at L.F.

The original article contains a great deal of important and interesting information on the subject, the value of which can only be appreciated when studied with the tabulated data and graphs which accompany the original text. It concludes with a very useful bibliography of the works dealing with the subject.

The section of the volume dealing with " International Time and Weather Signals " contains a few introductory remarks, wherein it is pointed out that the war has brought added dangers, *e.g.*, minefields, to those with which the navigator has had to contend under normal circumstances ; this makes it incumbent upon him to navigate his ship nowadays with more than usual exactitude. Since the accuracy with which a ship's position can be fixed depends on the correctness of the ship's chronometers, wireless time-signals have acquired a much enhanced value for navigation purposes.

The utilization of wireless telegraphy for the dissemination of weather signals, as adjuncts to scientific farming, is touched upon as one of the possibilities of the immediate future.

The information given in relation to time signalling and meteorological services in the volume under review contains a great deal of matter that is published for the first time in the *Year-Book ;* it is a collation of the operations carried out at various wireless stations in different parts of the world.

Under the title " Notes on Valve Patents published in 1917," Mr. I. Shoenberg contributes a considerable volume of valuable information on this important device, the very peculiar and significant feature whereof consists in the manifold applications to which it lends itself so admirably ; the variety of these applications comes out very clearly in the specifications analysed by Mr. Shoenberg.

In an article entitled " Wireless Possibilities," Mr. A. R. Burrows deals with speculations upon the future of radiotelegraphy and allied developments and the forthcoming demand in Anglo-Saxon countries for specialists in this rapidly widening field of activity.

Many mysterious happenings have occurred during the period of the great world contest ; warships consisting of the finest products of modern engineering have gone sky-high when lying peacefully at anchor ; airships have, without any apparent reason, fallen suddenly to earth a heap of ruins. The word " wireless," Mr. Burrows tells us, has been whispered abroad as the mysterious agent of destruction in such cases. Discussion of the subject is under restrictions, so that it would be unprofitable further to pursue the matter here, apart from stating that the credence attached to such suggestions indicates very clearly a certain inherent faith in the possibilities surrounding etheric phenomena.

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It is stated in the original article that " one of the most interesting possessions of Marconi's Wireless Telegraph Company is a collection of Press cuttings dating from the time of Mr. Marconi's arrival in England. In view of the present position of radiotelegraphy, many of these cuttings read like extracts from comic journals, and not the serious expressions of weighty organs of public opinion. Nothing could demonstrate more clearly the ease with which dispassionate thought can be disturbed and how powerful are the human frailties which serve to retard evolution."

The obstruction and difficulties with which Mr. Marconi had to contend as soon as he arrived in England are briefly touched upon by Mr. Burrows. Mr. Marconi, however, decided to peg on and eventually reaped the reward of his perseverance. Under the heading " Seventeen Years Ago " a reference is made to the epoch-making events of December 12th and 13th, 1901, connected with the reception at St. Johns, Newfoundland, of the signals sent out from Poldhu. It is now a case of " Looking Ahead " ; those who are in a position to express a sound opinion on the subject predict that a vast extension of the application of " wireless " to ordinary commercial purposes must certainly take place in the immediate future. A sign of the times, it is pointed out, is provided in the announcement that a French transocean cable company has definitely decided to erect a wireless station for the conduct of uninterrupted communication between France and the United States. Germany makes no secret of the fact that she expects her high-power station at Nauen to be her sole direct means of communication with the outer world for some period after the War.

Many of the possibilities of long-distance wireless telegraphy are touched upon by Mr. Burrows, among which he includes the peace-time dissemination by wireless of international information.

In a section entitled " The Wireless Telephone," it is pointed out that although the War has to some extent hindered the development of this branch of the wireless art, yet the fact remains that wireless telephony over distances even transoceanic in extent has already been accomplished. Speech so transmitted very nearly approaches the technical quality of direct conversation.

One of the logical but unwelcome developments of wireless telephony may, it is suggested, turn out to be " audible advertisements " ; at the present time a field for such a use of this means of communication exists in connection with the financing of the War and it is hinted that wirelessly operated megaphones might even to-day be established at the traffic centres with profit to the State.

Under the title " 'Twixt Earth and Heaven," it is pointed out that " in the intensive commercial life which will be thrust upon us to make good the ravages of the present conflict there will certainly arise a need for such speedy long-distance transit as the aeroplane alone can afford. . . . One of the essentials for long-distance aerial traffic will be a complete wireless system enabling the aeroplane to keep in touch with mundane affairs throughout the journey, and to signal in turn to stations below as the journey progresses."

The wireless equipment, under such circumstances, would further

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render aerial navigation relatively independent of weather conditions affecting visibility over land or water.

The suggestion is thrown out that lighthouses may at some future time be controlled from shore by impulses radiated at sundown and sunrise and at such times as storms break over the neighbourhood. Were this done, there would no longer be any necessity for many groups of watchers being kept in close confinement in isolated homes; in their place there would be needed only an inspecting staff to refil gas containers and make any necessary adjustments from time to time.

Under the title "In the Backwoods" Mr. Burrows deals with the possibilities of utilizing wireless direction-finders for triangulation purposes and points out that by wireless means vast areas of territory can be surveyed at a speed impossible by any other method at present known.

The uses of wireless telegraphy in connection with Polar exploration, for the purpose of notifying storm damage in remote regions, and for assisting police to keep in touch with their headquarters when patrolling by motor-car on land or by boat on water, are touched upon briefly in the original article. The announcement made by the Admiralty last autumn in relation to an attack upon British ships by an electrically-controlled boat also comes in for mention and the imagination of man is stirred by a reference to the fascinating problems connected with the wireless control of torpedoes and similar devices which still await solution on a practical scale.

Mr. Burrows concludes his article by pointing out that "A Wide Field for Young Anglo-Saxons" to busy themselves in exists in connection with "wireless" research and "wireless" engineering.

In an article entitled "S.O.S." Mr. H. J. B. Ward gives an outline sketch of wireless achievements in life-saving at sea. A reference is made to the Orders in Council issued under the Defence of the Realm Act, wherein provision is made that British ships of 1,600 tons and over shall in future be equipped with wireless telegraphy and it is pointed out that in many other countries legislation on similar lines has been instituted in relation to their mercantile fleets.

A schedule of "Timely Rescues" accompanies the article; this schedule is, in the present state of affairs, necessarily incomplete, but the details given provide the reader with almost inexhaustible material for the exercise of what may appropriately be termed the pictorial side of mentality.

An extract is given by Mr. Ward from an account printed in a current magazine, wherefrom we learn of the admirable manner in which wireless has been utilized for "shepherding" a vessel from the start of its voyage to the finish.

The immense German projects for mercantile expansion the moment that the British Fleet "ceases from troubling" and in which radio-telegraphy is to play a conspicuous part are touched upon in the original article.

It is pointed out that many exploits of wireless remain unrecorded in the schedule referred to earlier. The *lacunæ* must be laid mainly at the door of the exigencies of the times; the censorship is, and naturally must be, rigidly exercised in relation to all information of a military character.

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Especially does this hold true in the case of transports ; some day we may learn something of what wireless has to its credit in this connection.

An introduction to the schedule of British Applications for Patents is provided under the heading " Particulars of Wireless Telegraph Patents in 1917," wherein we learn that the character of the times we live in is depicted by the steady concentration shown by inventors upon the methods of and means for waging a successful war. The total number of applications for patents filed in 1917 exceed by about one thousand those filed in 1916 ; those having reference, both direct and indirect, to " wireless " total but 160 in 1917 as compared with 190 in 1916. The present year has witnessed steady concentration upon receiving apparatus of the Fleming valve type.

The concluding portion of the volume contains a " Useful Data Section " *i.e.*, Definitions of terms used in Wireless ; a dictionary of technical terms in English, French, Italian, Spanish and German ; useful formulæ and equations ; international units and symbols ; relation between sparking distances and impressed voltage ; a specific electrical resistance table ; specific inductive capacities ; wire tables ; Gilbert's Table (ordinary catenary) ; table showing maximum current permissible with various classes of wire ; data for B.H. curves ; weights and measures ; length of a degree in latitude and longitude ; specification of the Beaufort Scale ; measures of time ; standard or zone time ; foreign and colonial money ; particulars of the leading companies engaged in the commercial development of wireless telegraphy ; biographical notices of those prominently associated with wireless telegraphy ; a comprehensive bibliography of works on wireless telegraphy and telephony ; a directory of Wireless Societies ; Code Signals ; and finally, Lloyd's list of signal stations.

The utility of the volume under review to every one interested, however remotely, in wireless telegraphy and telephony is unquestionable ; the foregoing enumeration of its contents indicates the very wide range of matters connected with the subject that are contained within the covers of the *Year-Book*.

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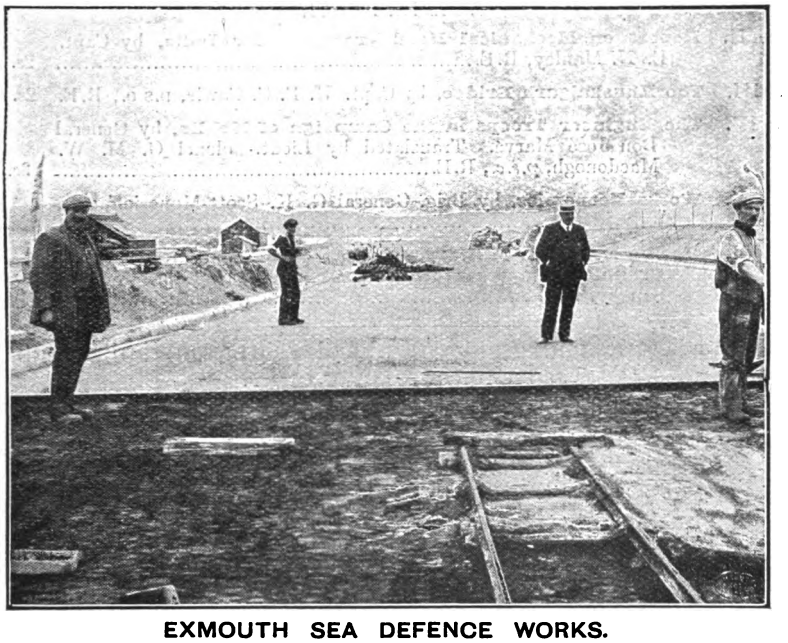

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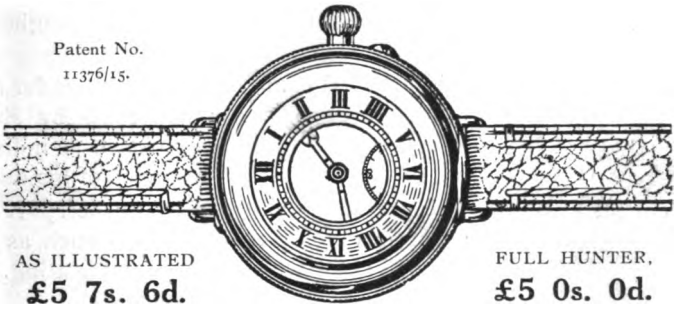

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MILITARY EXPLOSIVES OF TO-DAY.

Cantor Lectures by J. Young, Esq., O.B.E., delivered before the Royal Society of Arts on April 8, 15, and 22, 1918. These Lectures are published by permission of the Royal Society of Arts in anticipation of their appearance in the Society's Journal.
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LECTURE III.

HIGH EXPLOSIVES FOR SHELL FILLING.

A HIGH explosive, in order to be suitable for shell filling, must possess special qualities not necessary when it is used for other purposes, even in bombs and torpedoes. *Firstly* it must have great power, that is give much gas and heat. *Secondly* it must be insensitive enough to stand the great shock of firing, and even the impact on an armour plate, without detonating the latter, so that it may penetrate before the fuze acts. *Thirdly* it should have a high density, so that a large weight may be enclosed in the limited space, and a high velocity of detonation, so that it may have a great shattering effect. *Finally* it must detonate completely and with certainty when required, by the action of a detonator which is itself not too sensitive to stand the shock of firing.

These provisos exclude all the nitroglycerine and chlorate explosives, which are too sensitive. Also the ammonium nitrate class, such as ammonal, which are too insensitive, and require a fulminate detonator. Large fulminate detonators in a shell are unsafe, and may lead to prematures, although they have been used. The problem of detonating a shell safely and with certainty is the most difficult of all, although it has been solved fairly satisfactorily now. When a shell merely explodes (*i.e.* the filling burns) the action is so slow that the shell breaks up, a large amount of the filling is blown away unburnt, and very feeble effects are produced. Many of the lyddite shells used in the South African War behaved in this way, and except for emitting poisonous vapours did little harm to the enemy.

None of the shell H.E. possess all the desirable qualities. Those now in use have little more than half the shattering power of blasting gelatine. All are products derived from the distillation of coal.

Formerly gunpowder was the only explosive used in shells. Sprengel pointed out in 1871 that picric acid could be detonated, but no attempt was made to use it. A new epoch in shell filling was commenced in 1885 when M. Turpin showed that picric acid, when brought into a dense and homogeneous state, made a safe filling for shells, and could be detonated with tremendous shattering effect. It was adopted by the French under the name of Melinite. Later by the

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British under the name of Lyddite. Other nations also adopted it under various fancy names. Still later tri-nitro-cresol, tri-nitro-toluene, and other aromatic nitro-compounds of a similar nature were introduced, and are now used.

As previously stated the basic substances required for the manufacture of these explosives are obtained from coal. When coal is distilled in the manufacture of coal gas about 16 to 20 gallons of tar are obtained from each ton. The tar is a complex mixture, and contains only about ½ lb. of benzene, toluene, and xylene, required by the explosive manufacturer. The coal gas contains about 1 per cent. by volume of the vapours of these substances, equal to about 19 lbs. per ton of coal. Formerly this was allowed to remain in the gas, and was the cause of the greater part of its luminosity when burnt in a flat burner. But on the advent of War, and the urgent demand for these hydrocarbons, it was necessary to "strip" the gas, or rob it of these constituents, a process already in use in connection with the gas from coke ovens. The result is that the normal luminosity of coal gas has decreased, but this has not much effect on its heating power and use in incandescent burners, while 13 to 20 lbs. of these mixed hydrocarbons in the form called benzol are now extracted from each ton of coal. A writer in *The Times* Engineering Supplement states that 40 millions of gallons of benzol can be obtained from the gas works of Great Britain, in addition to 60 millions already obtained from the coke ovens.

When coal tar is distilled the first portion which comes over at temperatures up to 150°C. is called the "light oil," and is crude benzol, mostly benzene and toluene.

In order to extract the hydrocarbons from coal gas it is submitted to a washing action by a solvent. At first coal tar was used, but the best solvent, and that now generally used, is the "green oil," itself a special high-boiling distillate from the tar. The oil absorbs the benzol, and is afterwards heated and allowed to flow down over a series of superposed cast-iron trays, up through which a jet of steam is passed. The steam vaporizes the hydrocarbons, which are carried away and condensed. The oil is returned to the scrubbing plant and can be used over and over again.

The composition of the benzol varies with the quality of the coal used and the process of stripping. It contains 50 to 70 per cent. of benzene, 10 to 40 per cent. of toluene, 1 to 3 per cent. of xylene, and smaller amounts of naphthalene and acids. These substances are afterwards separated by fractional distillation. At present there is a great demand for toluene, but the benzene is also used as a nitro-compound in explosives, and in a synthetic process for making phenol.

The next fraction from coal tar distillation—the "middle oil"—contains phenol and other bodies, and the later fractions—the "heavy oils"—also contain valuable compounds.

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Phenol, C_6H_5OH, commonly called Carbolic Acid, is obtained from the middle oil of tar distillation. The oil is treated with caustic soda, which dissolves the phenol, cresol, and similar bodies. The solution is removed and treated with sulphuric acid, which precipitates the phenol, etc. The phenol is then separated by distillation. Pure phenol forms a mass of crystals somewhat like sugar in appearance and very different from the crude black liquid called carbolic acid used as a disinfectant. Pure phenol melts at 44°C. and boils at 182°C.

Picric Acid, $C_6H_2(NO_2)_3OH$.—When phenol is added to conc. nitric acid a violent reaction takes place, and the tri-nitro compound is formed.

$$C_6H_5(OH)+3HNO_3=C_6H_2(NO_2)_3OH+3H_2O.$$

Phenol. Nitric acid. Picric acid.

Other reactions take place simultaneously, and resinous compounds are formed. In practice the manufacture takes place in two distinct stages. The methods and proportions of acid used vary considerably. The following method works well.

First the phenol is mixed with its own weight of conc. sulphuric acid, and heated to over 100°C. for some time. It combines with the acid to form phenol sulphonate, $C_6H_4OHHSO_3$.

The sulphonate is mixed with water and added, a little at a time, to conc. nitric acid. The mixture is kept cool at first, and a di-nitro is formed. Afterwards it is heated by steam for several hours until all oily matters have disappeared, and a clear yellow liquid is formed. This liquid is next allowed to cool, and crystals of picric acid are deposited. The crystals are thoroughly washed with water until free from acid, and wrung as dry as possible in a centrifugal machine. They are afterwards spread on glass tables and dried in air at about 50°C.

Picric acid forms yellow needle-shaped crystals, melting at 122.5°C. when pure. Any impurity lowers the M.P., so this is the best test for purity. It is slightly soluble in cold water, has an intensely bitter taste, and is poisonous. Its chief use formerly was as a dye for silk and wool.

When heated to about 300°C. it inflames, and burns with a hot flame, and clouds of black smoke containing free carbon. A large mass thus inflamed will burn for a while, but owing to the heat given out will probably end by detonating. A small quantity thrown on a red-hot plate flashes off ; when the plate is white-hot it may detonate. It is not very sensitive, and will only just detonate when hammered on an anvil. ½ gram of mercury fulminate will set up the detonating wave, 1 to 2 grams will detonate any quantity with certainty, even in its densest form. It can also be detonated by picrates and some other compounds less sensitive than fulminate, and these are used in shells.

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Use in Shells.—The picric acid is melted in baths heated by oil or hot air and poured into the shell, which is cleaned inside and lined with a non-metallic varnish. A former is placed inside and removed when the acid sets, so as to leave a central cylindrical cavity for the exploder. In this cast form it has a density of 1.62, and is called Lyddite. In this form it is the most powerful and shattering explosive used in shells. When fully detonated it gives a cloud of black smoke, owing to its deficiency in oxygen, and this is useful for observation purposes, and also for indicating to the gunner that his shells are detonating and producing the desired effect. When the detonator fails, and the shell merely explodes, the action is slow, and much picric acid vapour is blown out, so that the smoke is yellow. The effects are very feeble, although the vapours are poisonous.

The rate of detonation is about 7,700 metres per second.

In spite of its great merits picric acid has now been largely replaced as a shell filling by tri-nitro-toluene and amatol, for the following reasons :—

Defects of Picric Acid.—First, the high melting point prevents the use of low pressure steam as a heating agent, and involves methods which constitute a certain danger. *Second*, picric acid is a true acid, and when in contact with metals, or metallic compounds such as rust, lime, plaster, lead paint, etc., forms picrates. All picrates are much more sensitive than the free acid to simple shock ; the heavier the metal the more sensitive the picrate, and lead picrate is very sensitive and powerful. If a small amount of one of these was in the shell it might be detonated by the shock of firing, and the detonation would extend to the filling causing a premature, and the destruction of the gun and detachment.

This may be illustrated by mixing some picric acid with an equal bulk of lead peroxide or red lead, and heating as much as would lie on a sixpence on a tin plate. The mixture detonates with a force only less than that of nitroglycerine and blows a hole in the plate. The mixture also detonates violently by moderate percussion on an anvil.

Hence all operations connected with the preparation of picric acid, the shell filling, and inspection of shells, must be conducted in rooms free from lime or plaster. The shells must be clean and lined with non-metallic varnish. No lead paint is used even on the outside, and no lead alloys in the fuze or anything which would come into contact with the filling.

Given that the picric acid is pure, and proper precautions have been taken, it is quite safe and the most powerful shell filling in use. It is also unaffected by high atmospheric temperatures, unlike T.N.T., and is specially suitable for tropical climates. The problem of detonating a lyddite shell safely and with certainty is now solved,

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although this was not the case during the Boer War, or even in the early days of the present War.

Picrates.—When a hot saturated solution of picric acid is mixed with a solution of a metallic salt a picrate is formed, and is easily crystallized out. With potassium carbonate potassium picrate, $C_6H_2(NO_2)_3OK$ is formed. This, mixed with potassium nitrate, has been used for charging torpedo warheads. With ammonia ammonium picrate is formed, $C_6H_2(NO_2)_3ONH_4$. Forty-three parts ammonium picrate and 57 parts of potassium nitrate form picric powder. It is used as a detonator for lyddite shells.

Tri-Nitro-Cresol.—Cresol, $C_6H_4OHCH_3$ is a very similar compound to phenol, and also obtained from coal tar. When nitrated in the same way it forms a tri-nitro-cresol, $C_6H(NO_2)_3OHCH_3$. Its properties are very similar to those of picric acid, and it has been used as a shell filling. In Austria it is called Ecrasite; in France Cresylite. In France it is mixed with picric acid in order to produce a Melinite of a lower melting point.

Tri-Nitro-Toluene, $C_6H_2(NO_2)_3CH_3$.—Usually called T.N.T. This substance, at present the most important of the shell high explosives, is known in the Service as Trotyl, and is used in other countries under various fancy names, such as Tolite (France), Trilite (Spain), Tritolo (Italy), etc.

It is made by nitrating the hydrocarbon toluene, obtained from the distillation of coal as previously described. The toluene for this purpose must be pure, clear, and water white. Boiling point, 110°C. When treated with a mixture of conc. nitric and sulphuric acids it is converted successively into the mono, di, and tri-nitro compounds. The following equations represent the successive steps:—

(1). $C_6H_5CH_3+HNO_3=C_6H_4NO_2CH_3+H_2O$.
(2). $C_6H_4NO_2CH_3+HNO_3=C_6H_3(NO_2)_2CH_3+H_2O$.
(3). $C_6H_3(NO_2)_2CH_3+HNO_3=C_6H_2(NO_2)_3CH_3+H_2O$.

The sulphuric acid combines with the water liberated in the reactions.

The complete conversion into the tri-nitro is a long and difficult process, and different methods are used in different works. In some it is done in one operation by the long continued digestion with the mixed acids. In others there are two stages. First a conversion into the di-nitro, and then by a treatment with fresh acids a conversion into tri-nitro. In others the conversion is done in three stages.

In one method 1 part of toluene is run into 1.7 parts by weight of mixed acids containing 3 parts sulphuric to 2 parts of nitric. The pan is steam jacketed, and the result of the reaction is mono-nitro toluene.

When the reaction is over the acid is run off, and a fresh acid mixture run in and the pan heated. The di-nitro compound

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is the result of this reaction. The di-nitro-toluene, which is a liquid at this temperature, is run off and allowed to solidify.

The di-nitro is next heated with conc. sulphuric acid until it dissolves, and then run into a pan containing one and a-half times its weight of conc. nitric acid, the mixture being kept cool by coils of lead pipe in which cold water is circulated. The mixture is next heated to about 100°C. for several hours, until gas is no longer evolved, being kept well stirred. This action converts most of it into the tri-nitro.

The conversion by a continuous process in one operation has been greatly improved recently, and is now much used.

The acids are then run off, and the still liquid substance well washed with hot water and dilute soda. When it cools it is crude, impure, tri-nitro-toluene, and melts at about 70°C.

Purification.—The crude T.N.T. made in this way contains impurities, mostly lower nitro-compounds, and isomers of the true T.N.T. The chief of these are oils at the ordinary temperature, and their presence is indicated by a lowering of the melting point. Pure T.N.T. melts at 81.5°C., but the final purification is so difficult that a product which melts at 80°C. is called " pure."

The chief objection to the presence of these oily impurities is that if the T.N.T. is used as a shell filling, either alone or in one of the higher grades of amatol, the oils have a tendency to separate, and this tendency is increased by a rise in temperature, or pressure in the shell caused by evolution of gas which sometimes occurs. The oils penetrate porous substances sometimes used to contain the exploders, and creep past the threads of screws. When they enter the gaine exploder and wet the contents these become insensitive. If the shell is fired in this condition it will fail to detonate and is a " dud." A new exploder, however, will remedy matters.

Various methods of purification are used. Treatment of the finely-divided substance with hot water in a centrifugal machine has given good results. Washing with cold alcohol is also used, as the impurities are more soluble than the pure T.N.T. For the highest grade of purity the substance is dissolved in hot alcohol and allowed to crystallize out.

Properties.—Pure T.N.T. forms yellow crystals melting at 81.5°C. They are insoluble in water. When heated to about 300°C. T.N.T. ignites and burns with a hot, but very smoky flame. When a large, mass is involved the heat given out will invariably raise the temperature to the detonating point. The disasters in East London and at Halifax are examples of this. When fires of this extent are once properly going it is hopeless to attempt to extinguish them. The most sensible thing to do is to clear the premises and let matters take their inevitable course. It is more insensitive than picric acid and very difficult to detonate by hammering. It is fully detonated by

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fulminate, except when in the form of cast slabs untamped, when the addition of a little lead azide to the fulminate is necessary. Fulminate detonators are used in bombs, torpedoes, and grenades. It can also be detonated by less sensitive substances, such as picric powder and tetryl, and these are used in shells. Its density when melted and cast is 1.55—1.6.

T.N.T. is even more deficient in oxygen than picric acid. When fully detonated the gases liberated consist of CO, H_2, and N_2, and the free carbon liberated forms a thick column of black smoke—hence the name "coal boxes" and "Jack Johnstons." The velocity of detonation in its densest form is about 7,000 metres per second. The power is less than that of picric acid about in the proportion of 91:100. Owing to the inferior velocity of detonation the shattering effect (brisance) is proportionately still less, about 87:100.

Advantages of T.N.T.—The special qualities of T.N.T. which has caused it to largely replace picric acid as an explosive are as follows:—

(1). Its lower melting point renders it much safer during the melting and manipulations required in shell filling. (2). It is a neutral substance, and does not form sensitive compounds with metals and their oxides like picric acid, so no particular care is necessary in cleaning and lining the shells, lead-free paint, etc. Alkalies, however, diminish its stability and render it sensitive, so shells should not be cleaned with caustic soda. (3). It can be mixed safely with oxidizing agents, which is not the case with picric acid. As little as 10 per cent. of T.N.T. mixed with ammonium nitrate gives an explosive as powerful as the pure substance itself. The amatols thus made more than double our resources as regards high explosives.

Only the highest grade of purity is used, as crystals and pellets, in the exploders for H.E. shells. A slightly lower grade is used for filling shells and for making shell amatol. The more impure substance, with a melting point 5 or 6 degrees below normal, is used for making amatols with a high percentage of ammonium nitrate, from which the oils are less likely to separate. This is suitable for mining, bombs, grenades, etc. For shells to be used in the tropics only the purest, T.N.T. is suitable.

In shell filling the T.N.T. is melted in steam-heated pans and poured into the shell, where it sets into a yellow crystalline mass. A central cavity is left for the exploder. The detonating arrangements are mentioned later.

Amatol.—Amatol was dealt with in the first lecture. That with the higher proportions of ammonium nitrate, such as 80/20, is more difficult to detonate than when the proportion is lower, and is used in cases where fulminate detonators are used. The mixture most used in shells is 40/60. The mixing and introduction into the shell is done in various ways. Sometimes the T.N.T. is melted and the

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powdered nitrate stirred in. The plastic semi-liquid mixture is poured into the shell. Sometimes it is milled cold, the powder introduced into the receptacle and stemmed (compressed), or it is compressed into slabs which are then packed in. The same exploder is used as with pure T.N.T.

When an amatol shell detonates there is only a little grey smoke, and no definite indication as to whether detonation has been complete or not. For observation purposes a packet of smoke producer is put in. The power is a little greater than that of pure T.N.T., but the velocity of detonation much less—4,000 to 4,500 metres per second, so that the local shattering effect is much less. For some purposes this is even an advantage.

Amatol is the most used of all the shell H.E. at present.

Tetra-Nitro-Methyl-Aniline, $C_6H_2(NO_2)_4NCH_3$.—This substance is known in the trade as Tetryl, and in the Service as C.E. (Composition Exploding). It is made by nitrating methyl or di-methyl aniline, substances used on the large scale in the manufacture of aniline dyes. The substance is dissolved in ten times its weight of conc. sulphuric acid, and the solution added slowly to $4\frac{1}{2}$ parts of nitric acid of sp.g. 1.48. The temperature is kept between 44 and 55°C. On cooling crystals of the substance are deposited, and are washed with water. It is completely purified by crystallizing it from its solution in acetone, but inferior grades of purity from nitric acid and boiling water are in use for some purposes.

Properties.—It forms crystals of a fine yellow colour, melting at 129—130°C. It is more sensitive than picric acid, and can be detonated readily by hammering. When ignited it burns with a very hot smokeless flame, and flashes off when thrown on a red-hot plate. It is readily detonated by a very small charge of fulminate, such as that used in shell detonator caps; is very powerful, and has a velocity of detonation of over 7,000 metres per second. It is an excellent initiator of detonation in other less sensitive explosives.

Uses of Tetryl.—As tetryl (or C.E.) is an excellent initiator of detonation, and has a sensitiveness intermediate between that of fulminate and ordinary shell fillings, it is much used as an intermediary. It is used in the form of powder, grains, and compressed pellets or cylinders up to a few ounces in weight. It is sometimes added to fulminate in ordinary detonators. Compressed cylinders are used in the magazines of some fuzes. In powder, pellets, and cylinders it is used in the gaines or detonators for T.N.T. and amatol shells, with which it is very effective.

The Germans also use a compressed cylinder of C.E. as the H.E. charge for some gas shells. The uses of C.E. are extending, although it will probably prove too sensitive, as well as too expensive for use as a complete shell filling.

Tetra-Nitro-Aniline, $C_6H(NO_2)_4NH_2$.—This substance is made by

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the nitration of ordinary aniline. It has great possibilities, although not adopted as a Service explosive. It is a yellowish powder which cannot be melted without decomposition. When ignited it flashes off without smoke. Its sensitiveness to blows is about the same as that of C.E. It is easily detonated by fulminate, and is said to be as powerful as pure nitroglycerine if not more so.

It is probably too sensitive to be safe for use as a shell filling, although there seems no reason why it should not be used for other purposes. It is said to have been used in shells during the present War, but not in our Service.

Hexa-Nitro-Diphenylamine $(C_6H_2(NO_2)_3)_2NH$.—This is made by nitrating diphenylamine. It is a yellow powder which does not melt. It is a powerful H.E., but rather too sensitive for a shell filling. A mixture of this with T.N.T. has been used by the Germans in aerial bombs. They also use it as H.E. in some gas grenades.

Tri-Nitro-Anisol, $C_6H_2(NO_2)_3OCH_3$.—This substance is made by the nitration of anisol, a liquid. Chemically it resembles picric acid. It has been used in shells and bombs.

Nitro-Benzenes.—Benzene also gives a series of high explosives. Di-nitro-benzene, readily formed by the action of mixed nitric and sulphuric acids on benzene, is a yellowish solid. It is too deficient in oxygen to be a good explosive in itself, but when mixed with oxidizing agents is a powerful explosive. Thus, Bellite and Roburite are mixtures of di-nitro-benzene and ammonium nitrate, the latter having a little nitro-naphthaline added as well. Bellite is used in grenades.

Tri-Nitro-Benzene, $C_6H_3(NO_2)_3$.—This is also made by the nitration of benzene with mixed nitric and sulphuric acids, but the process is a long one, and full nitration difficult, which has prevented its being used to any great extent. It resembles T.N.T., but is a more powerful explosive.

Methods of Detonation.

Initiators of Detonation.—Detonation can be set up in a H.E. charge by simple shock, and this is used in the case of percussion caps, but with large charges a combined shock and intense heat supplied by some sensitive substance is most effective in initiating detonation. The nature of the shock is important, and what is best for one H.E. is not necessarily best for another, but in all cases it must be very sharp and sudden, so as to produce momentary intense pressure. Fulminate of mercury is the most generally useful and effective substance for initiating detonation. It is also used in percussion caps for igniting powder charges.

Fulminate of Mercury, $C_2N_2O_2Hg$.—It is made by dissolving mercury in nitric acid and acting on the solution with alcohol. Various formulæ are used for its preparation. In one devised by

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Chandelon, and which gives good results, 1 part by weight of mercury is dissolved in 10 parts of nitric acid of sp.g. 1.4. When the solution is at 54.5°C. it is poured into 10 parts of alcohol of sp.g. .83. As much as 7 lbs. of mercury can be used at one operation. The preparation should be done in the open air, and involves a certain amount of danger.

For preparation on the small scale for experimental purposes, the following I have never known to fail :—

Dissolve 8 grams of mercury in 70 c.c. of conc. nitric acid of sp.g. 1.45 with the aid of gentle heat. When completely dissolved, and the temperature is not above 40°C. pour into it 90 c.c. of alcohol of sp.g. .87. All flames near should be extinguished. Next heat the beaker containing the mixture in a hot-water bath until bubbles begin to form and a reaction begins. The reaction is violent, and dense white fumes containing various nitro compounds are given off. When the reaction is nearly over fill the beaker with water. The fulminate will fall to the bottom. It should be filtered off and washed free from acid. It can be dried quickly by first washing with alcohol until free from water, and then with ether. In a few minutes it will be ready for use.

Fulminate is a crystalline powder, white when pure, but usually grey owing to some free mercury. It is the most sensitive explosive employed practically. Detonates easily between iron surfaces, can be detonated between lead and iron, but not between surfaces of wood. It is quite safe to keep when wet. It is usually dried by exposure to warm air (104°F.), and when dry, owing to its sensitiveness kept in packets of 120 grains as a maximum. When pure it will stand a high pressure, but with the least admixture of grit of any kind a slight pressure will explode it. It is insoluble in cold water and only slightly so in hot, 1 part in 130 of water.

When ignited in the open it burns with a very sudden flash, and slight report. But when even slightly enclosed, as in a thin copper tube, and ignited, the first few grains which burn produce sufficient pressure to detonate the remainder. It is this property which makes it of such efficacy in detonating other explosives. Its density is 4.4, and when highly compressed its detonation gives, probably, a higher instantaneous pressure than any other substance in use, except, perhaps, the azides.

Whether exploded or detonated the products are carbon monoxide, nitrogen, and mercury. $C_2N_2O_2Hg = 2CO + N_2 + Hg + 114{,}000$ cals. If some fulminate be sprinkled on a clean glass plate, and ignited, the mercury is deposited on the plate and forms a mirror, which makes a pretty experiment.

The flash from fulminate is too sudden to ignite gunpowder, which is simply blown away. When required in percussion caps for the ignition of cartridges it is mixed with potassium chlorate and

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antimony sulphide. This composition acts more slowly and gives a long, hot flame. Sometimes ground glass is added to increase the sensitiveness to percussion.

The Azides, derived from hydrazoic acid, N_3H, are even more effective initiators of detonation than fulminate. Where .25 grams of fulminate is the minimum which will detonate T.N.T. .05 grams of lead azide will suffice, and where mercury fulminate alone fails with cast slabs of T.N.T. untamped, an addition of lead azide succeeds perfectly. Lead azide, N_6Pb, is used to some extent at present, either alone or in combination with fulminate. Fulminate, however, is the standard.

The uses of Tetryl, Picric Powder, and some others as initiators of detonation will be referred to later.

Detonators.—Two varieties are in use, electric and non-electric. Non-electric detonators are thin solid-drawn copper tubes containing a charge of fulminate. The fulminate is compressed by about 60 kilos. on each, which gives it a density of about 2.2. The upper half of the tube is left empty for the insertion of the fuze, safety or instantaneous as the case may be, and is closed by a paper cap until required for use. The detonators are made in various sizes numbered from 1 to 10, and the numbers are common to all countries. No. 8, most used foi military operations, is 55 mm. in length and 6 mm. diameter, and contains 2 grams of fulminate, No. 5, used for some hand grenades, is 30 mm. long and 6 mm. in diameter, and contains .8 grams.

Electric detonators are constructed so that they can be fired from a distance by aid of an electric current. The construction varies, but the diagram shows the principle. The lower part of the tube (which may be solid drawn, or the end merely sealed with a plug of shellac) contains the fulminate. Copper leads are inserted into the upper end, and these are bridged over by a fine wire of platinum or platinum-iridium alloy. The bridge is wrapped round with fluffy dry guncotton, or imbedded in a bead of priming composition, and the leads are sealed in position with sulphur or other insulator. When an electric current is passed through it the bridge fuzes, ignites the guncotton, and this fires the fulminate. That most used in our land Service has a bridge $\frac{1}{4}$-in. long which requires .8 ampere to fuze it, and contains 43 grains of fulminate.

The advantages of the electric detonator are many. It can be connected by cables to a point from which it can be fired with perfect safety. When once connected up it can be tested by a small current, and if necessary be left for months, yet be fired at a moment's notice. Also, a number of detonators in charges can be connected to a single firing point and fired simultaneously. Great use is made of this where a number of land mines have to be fired in one operation. The

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current is usually supplied by the Hand Dynamo Exploder, where not more than—say 15—detonators have to be fired at once. For larger numbers a dynamo, or battery of accumulators, is used for certainty.

For hasty demolitions under stress of an enemy advance the ordinary detonator and fuze are used.

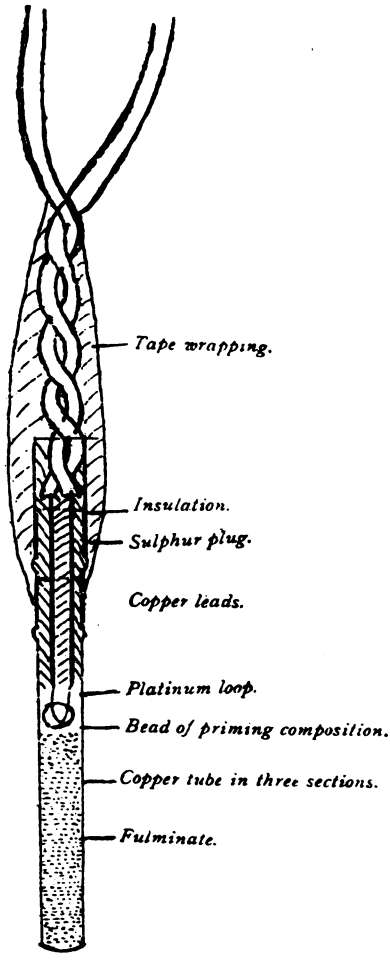

FIG. 1.—*Electric Detonator.*

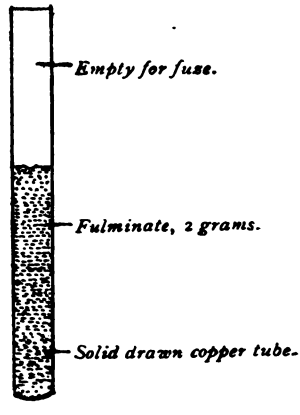

FIG. 2.—*Non-Electric Detonator, No. 8.*

Detonation of Charges of H.E.—When the charge to be detonated is not liable to be submitted to any sudden shock, which is the case with land mines, aeroplane and trench mortar bombs, grenades, and even torpedoes—in fact all except shells to be fired from a gun, the

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problem is simple. The charge is built up in position, the cartridges being packed in their original cases in land mines. In the case of grenades, bombs, etc., a detonator is inserted and a piece of safety fuze inserted in the detonator. With torpedoes a specially large detonator to be fired by percussion is used. Aeroplane bombs are also fired by percussion. For land mines with large charges amounting to tons it is advisable to use several detonators distributed throughout the mass, if this is of one of the slower acting ammonium nitrate explosives, and even primers of blasting gelatine or dynamite may assist. The charge is properly tamped, openings being left for the insertion of the detonators. When fulminate detonators are used in this way failures are very rare.

Detonation of H.E. Shells.—The problem of the detonation of a H.E. shell is much more difficult. The shell is subjected to an enormous shock in the act of firing, the detonating charge must be in intimate contact with the filling, and if fulminate were used there would be a great risk of this being detonated by the shock. This would detonate the shell in the gun, the gun would be destroyed and probably the detachment.

On the other hand, when a less sensitive detonating charge is used, which at present means a less efficient one, there is a risk of failure. The shell may merely explode, with very feeble effect. This was frequently the case during the Boer War. The problem seems to have been solved by the introduction of the gaine method.

The Gaine.—The gaine is a metal tube screwed to the fuze which enters a cavity in the filling and makes good contact with it. This is very necessary. It contains a chain of substances, about four, of decreasing order of sensitiveness starting from the fuze, and increasing order of violence of explosion Use is made of the fact that a substance in powder is more easily detonated than when in compressed pellets, and pellets than a cast dense solid. The actual substances vary with the shell and nature of the filling, but always start with gunpowder, which is very certain in action. Thus we may suppose the chain to consist of—(1). Gunpowder. (2). Tetryl powder. (3). Tetryl pellets. (4). T.N.T. pellets.

The action is started by a fulminate cap in the fuze, which fires the gunpowder. This partially explodes and partially detonates No. 2, which detonates No. 3 which in turn detonates No. 4, and this detonates the main filling. With fuze and gaine in good condition there are very few failures now.

The detonation of large shells is a simpler matter, as the walls are thicker and provide more efficient tamping. These are still often detonated by a single exploder charge of picric powder (for lyddite) in a recess in the filling.

The figure shows diagrammatically the arrangement of a shell with a gaine detonator. No details of construction are given.

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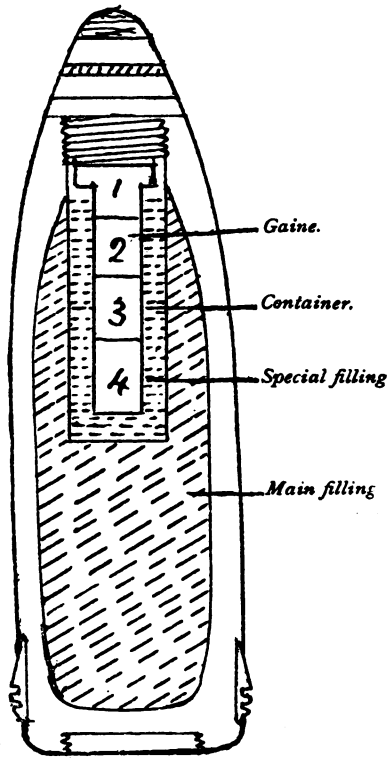

FIG. 3.—*H.E. Shell with Gaine.*

TESTS FOR EXPLOSIVES.

A large number of tests are applied to explosives for commercial use. Only an outline of those most important from the military standpoint can be given here.

(1). *Sensitiveness to Shocks.*—This is important with regard to explosives which have to be handled within reach of enemy bullets. It is usually tested by a *falling-weight apparatus*. About one-tenth of a gram of the explosive is placed on a small anvil, and a hard steel rod placed on top. A weight controlled by guide rods is allowed to fall on the rod, and the minimum height required to explode the charge is a measure of its sensitiveness.

According to this test the chief military explosives can be arranged in the following order of sensitiveness :—

Mercury fulminate.
Nitroglycerine (liquid).
Lead, copper, and iron picrates.
Dynamite No. 1.
Blasting gelatine.
Dry Guncotton.
Smokeless Powders (vary).
Chlorate Explosives (mining).
Tetryl (C.E.).
Picric Acid.
Tri-nitro-toluene.
Ammonium Picrate.
Wet Guncotton.
Gunpowder.
Ammonium Nitrate Explosives.

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(2). *Brisance* (local shattering effect).—For this test a cartridge of the explosive is placed on top of a steel piston, which rests on top of a copper cylinder placed on an anvil. The cartridge is detonated from the top by a standard detonator, and the shortening of the cylinder is a measure of the brisance. The Military Engineer has his own special tests, such as finding what weight of the explosive will cut a standard steel rail, untamped.

As previously explained the shattering effect is proportional to "Vol. of gas × Heat × Velocity of detonation." The following gives the order for the most important explosives :—

Blasting Gelatine.	Guncotton.
Dynamite No. 1.	Mercury fulminate.
Picric Acid.	Chlorate Explosives.
Tri-nitro-toluene.	Gunpowder.

(3). *Power*.—As previously explained the powers of different explosives can be compared by exploding a weighed charge of each in a modified bomb calorimeter, and measuring the volume of gas produced and quantity of heat evolved. The results are quite reliable. The best practical direct method of comparing powers is the "Trauzl lead-block test."

Trauzl Lead-Block Test.—A cylinder of lead 200 mm. in height and diameter has a hole 25 mm. diameter and 125 mm. deep bored in it. A charge of 10 grams of the explosive to be tested is put in, and a detonator inserted. The charge is tamped by sand and detonated. The increased volume of the hole is afterwards measured, and is proportional to the power of the explosive. The results are in fair agreement with the bomb-calorimeter method. Results are, however, really only comparable with explosives which have approximately the same rate of detonation, and discrepancies are explained in this way.

(4). *Test for Stability*.—This is a very important test. All explosives of the organic nitrate class, such as nitroglycerine, nitrocellulose, and mixtures containing them, which includes all the smokeless powders, are decomposing from the day they are made. The decomposition proceeds at an accelerated rate, and when it has proceeded to a certain point the heat given out may lead to a disastrous explosion where the explosive is stored in large quantities. This has frequently happened.

Several tests have been devised, some very elaborate, but that most generally useful is the original Abel's Heat Test. It is applicable to all explosives of the organic nitrate class, but not to aromatic compounds such as T.N.T., picric acid, etc. It depends on the following established facts :—

(1). During decomposition these organic nitrates give off nitrogen peroxide, NO_2, and a piece of paper treated with potassium iodide

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and starch is an extremely delicate test for NO_2, which stains it brown or blue.

(2). An increase of temperature accelerates the rate of decomposition. Roughly, guncotton decomposes as much in one minute at 77°C. as in two years in a store at say 15°C.

A standardized apparatus is used for the test, which must be carried out in a specified manner if results by different operators are to be comparable. Briefly it is done as follows :—

A small quantity of the finely divided explosive (1.6 grams for cordite, 1.3 grams for guncotton) is put into a test tube fitted with a rubber cork through which passes a glass rod ending in a platinum wire with a hook at the end. A piece of the test paper with its lower half moistened with dilute glycerine is suspended from the hook so as to hang a short distance above the explosive. The tube is immersed in a water bath kept at a constant temperature (82.2°C. for cordite, 76.6°C. for guncotton), and the time necessary to produce a brown line on the paper is noted, and is a measure of the stability.

This must be at least 10 minutes for guncotton, and 30 minutes for new cordite. Decomposition is so rapid in hot climates that 5 minutes will pass a cordite in India. The figure shows the appearance of the test tube when ready for the test.

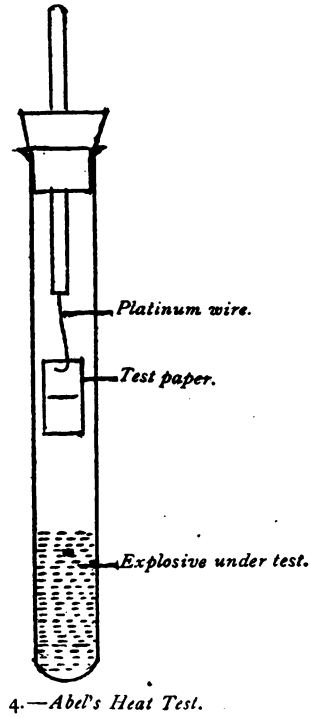

FIG. 4.—*Abel's Heat Test.*

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RATE OF DETONATION.—This is very important in the case of high explosives, but the apparatus is too elaborate to be described here. Dautriche's comparison method, in which the rate of detonation of a cartridge of the explosive is compared with that of a measured length of detonating fuze filled with T.N.T. having a rate of 6,000 metres per second is most useful. It will be found described in late standard Text Books, such as Marshall's *Explosives*.

Concluding Remarks.—From the foregoing it will be seen that although enormous work and research is being done, and new mixtures and modifications of old ones are making their appearance every day, there have been no startling discoveries in explosives during recent years. Practically the same explosives are being used by the different nations at war, and none can claim any advantage in that respect.

Also, there does not appear to be much prospect of obtaining more powerful propellants while proceeding on the present lines, as power depends more on heat than on gas, and high temperatures produce excessive erosion of the rifling. With regard to H.E. for shell filling there is still a wide margin, as T.N.T. has only about half the shattering power of blasting gelatine. It should be possible to find some compound equal in power to the latter, and sufficiently insensitive. Possibly a mixture of some substance like tetra-nitro-aniline with a small quantity of another which would reduce its sensitiveness would answer.

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DESTRUCTION OF TWO REINFORCED CONCRETE "PILL BOXES" ON MARCH 12th, 1918.

By LIEUT. R. SWIRE, 73rd (Field) Co., R.E.

THE two pill boxes in question were made by the Germans some time before April, 1917. They were in a very dominating position and were no use to us as they were dug into the forward slope of a hill and could not, therefore, be used for firing in the opposite direction. As they would have been most valuable to the enemy in the event of an advance it was determined to destroy them. The explosive used was blastine, fired electrically.

Pill Box No. 1.—For this pill box 400 lbs. of blastine were used, in two charges each of 200 lbs. fired simultaneously. First of all a sandbag wall two headers thick was built inside the pill box close up against the concrete, and stretching from Point A to Point B (see sketch). The top of the wall was about 9 in. below the bottom of the loopholes. On this wall a continuous charge of 200 lbs. of blastine was laid, in contact with the concrete, making a layer of explosive 10 ft. long by 1 ft. wide by 9 in. high. Two cartridges of blastine in this layer were opened, half the explosive poured out, a guncotton primer and electric detonator inserted, the explosive poured back and the cartridges fastened up again. This ensured that the detonators were thoroughly buried in the explosive.

More sandbags were then added on the top of and behind the explosive, carrying the wall up to within 10 in. of the ceiling. The layer of explosive not being so wide as the sandbag wall, it was possible to build it well in, the appearance from inside the pill box being that of a solid sandbag wall with the leads running into it.

The second charge was now laid on the top of the sandbag wall in an exactly similar way to the first, up against the roof, but was not tamped. The idea of this was to produce a great lifting effect on the roof while the front would be blown out by the first charge. The sides were unimportant as they would not be of any assistance to the enemy if left standing. The top charge had also two detonators, and all four detonators were connected in series. Finally the loopholes and doorway were blocked up with sandbags rammed tightly in so that there was no escape for the gases of the explosion.

In each charge five cartridges were opened and the contents poured over the rest. This was to ensure good contact between every

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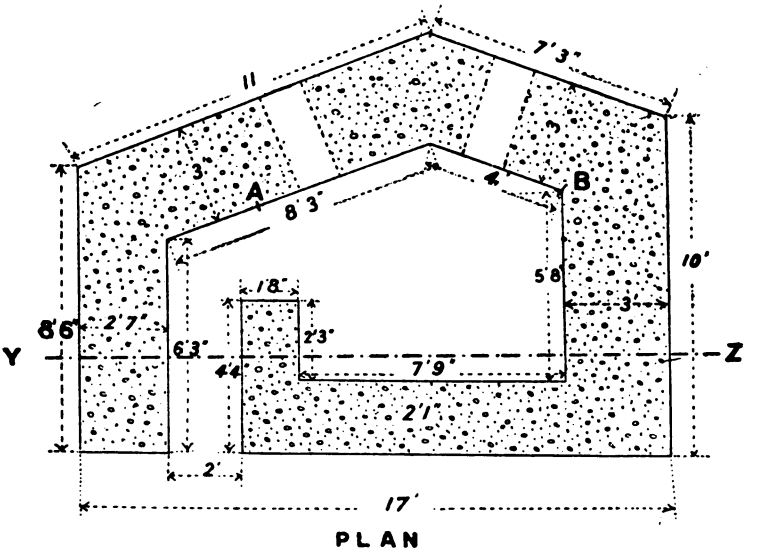
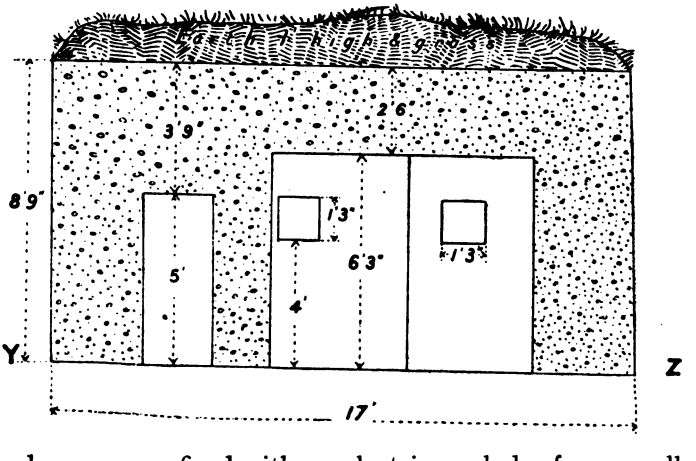
part of the charge as it was difficult to fit in the cylindrical cartridges and make sure of their all touching. In addition several primers and detonators were scattered about in each charge, but were not connected to the leads.

PILL BOX No 1.



PLAN

SECTIONAL ELEVATION THROUGH Y.Z



The charges were fired with an electric exploder from a cellar at a distance of 150 yards. The explosion was very soft, making very little noise but a certain amount of rumble. The result was the complete destruction of the pill box, not a vestige being left except a few pieces (presumably part of the foundations) in the bottom of a large crater. Pieces were scattered to a great distance, but in no

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case was a piece observed larger than an ordinary brick. Unfortunately it was not possible to find out the nature of the reinforcing as the demolition had to be done in one day and there was therefore no time to chip away the concrete and expose the reinforcing. I had hoped to be able to see something of it after the explosion, but nothing was left at all. For the same reasons nothing could be found out about the foundations.

Pill Box No. 2.—This was a fairly large work, with three chambers opening off a passage, and two observation posts with narrow slits for observers. In the roof of the observation posts there was a circular hole 1 ft. diameter covered by a movable iron plate. This must have been either for a periscope or for a disappearing machine gun. The observation posts were lined with 1-in. iron or steel plates and covered with concrete 1 ft. thick on the roof and 2 ft. thick round the sides. This raised portion of the roof (see *Fig. 2*) extended from the back edge of the pill box to the shoulder of the observation post, that is from A to B (*Fig. 1*). The whole pill box was underground except the roofs of the observation posts, ground level being about 3 in. below the observing slits.

It was decided to destroy the observation posts and to leave the chambers, as it would have taken a very big charge to destroy the whole building and there was not very much point in doing so. Blastine was the explosive employed, 100 lbs. being used in each observation post. First sandbags were built up on the floor of these posts to a height of 2 ft., then the explosive was laid round the walls, making a layer about a foot wide and 9 in. high. The two diagrams below explain the method of laying. Sandbags were afterwards built up behind and on the top of the explosive, completely filling up the observation posts.

As in Pill Box No. 1, some of the cartridges in each charge were opened and their contents poured over the remainder of the charge, to ensure good contact. Detonators and primers were also scattered about in the charge, and two electric detonators in each charge were connected to the leads, all four detonators in series.

The charges were fired from the same cellar as in the case of Pill Box No. 1; the resultant damage is shown approximately by the red dotted circles in *Figs. 1* and *2*. The observation posts were completely demolished, also the portions of wall AC and DE. The roofs of the two end chambers were badly broken in, and there was much more damage done downwards than had been expected. It is possible that the pill box was built not as shown in *Fig. 2* but with an empty space underneath the observation posts to economize material. This, of course, would not show while the pill box was standing and would account for the large amount of damage done to apparently very thick concrete. Presumably the reason why there was so much damage done backwards, completely demolishing part

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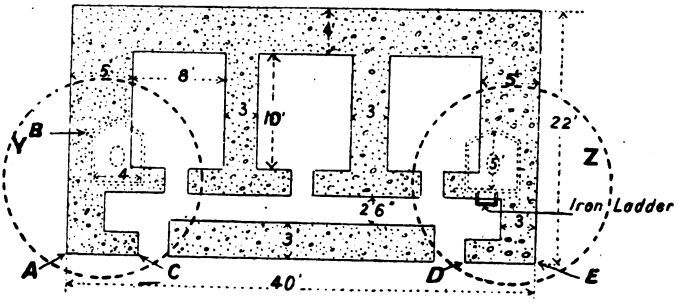
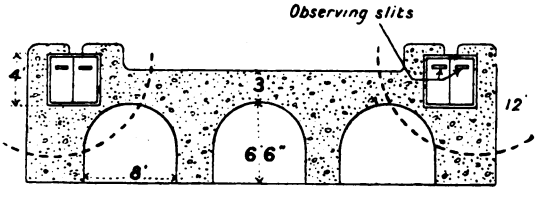
of the back wall was that the whole pill box was underground and therefore the front was immensely strong. The back was not up against any earth at all, a trench having been dug along it to admit of entrance.

PILL BOX No. 2.



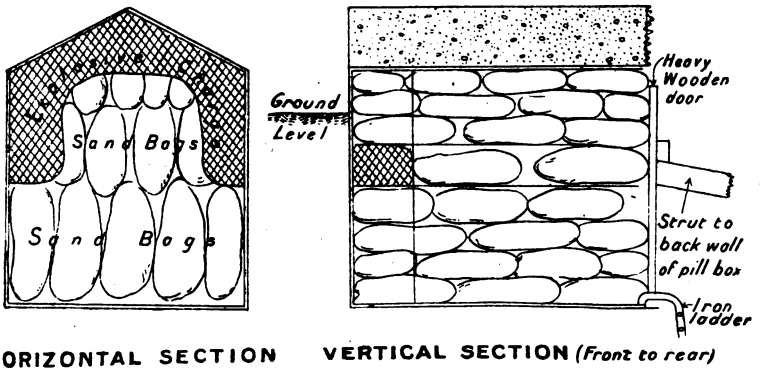
PLAN

FIG. 1.



SECTIONAL ELEVATION THROUGH Y.Z.

FIG. 2.



HORIZONTAL SECTION VERTICAL SECTION (Front to rear)

The work on these two pill boxes took six men about eight hours to complete. There was a great deal of heavy work in filling sandbags, etc., which could have been done quite well by unskilled labour. Apart from the actual laying of the charge the only work at all skilled was the sandbagging and the strutting up of the charges in Pill Box No. 2.

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THE DEFENCES OF DARDANELLES.

A REPORT WRITTEN IN 1799.

IN compliance with your Orders, I have in conjunction with Major Holloway, Commanding Royal Engineer, visited and examined the Defences, Batteries, Magazines, etc., at the Dardanelles.

When we consider the important and great national object they have to perform, nothing less than the preventing an Enemy's Fleet, from forcing a Passage, to the Capital of the Ottoman Empire; which would never be attempted, or undertaken, but by a force of great magnitude; we do not think the present works, were calculated upon so extensive a plan, as the momentous object entitles them to; and much fear, would not, under the present improved State of the Art of War, be found adequate to the great purpose for which they were built.

The Castles at the Entrance of the Dardanelles (Cumealli, on the Asia Side; and Setillahar on the Europe) are as well situated as the width of the Channel will admit of, being 4087 yards across, a distance rather too great for Artillery, to act with precision, nevertheless, an Enemy should be met as early as possible, and impeded step by step; we therefore think it was judicious to take up these two points.

The next point taken up, is for a Battery of Nineteen Guns, called Eskisar, on a high Cliff on the Europe side, to the Eastward of the Castle; and although a long and plunging range, will bring on with the Castle of Setillahar, an intersecting fire upon the entrance of the Straits; it should therefore be maintained and armed with Ten or Twelve good Guns, 24 Pounders: The Channel from this widens so much, that no further opposition can be made, until the point de Barbier presents itself, where a Battery for Six heavy Guns, should be made, as well as one of the same number and nature on the opposite Shore; these two Batteries would establish a good and certain intersecting Fire; and being prepared for firing red hot Shot, which all Sea Batteries should be, would impede the progress of an Enemy's Fleet, and make them very cautious how they approached the Upper Castles, Sultania, and Kelerbahar; these Castles are situated upon the narrowest part of the Dardanelles, but the position of the Castle of Kiletbahar, is not so well chosen as it might have been, had it been placed on the point to the westward of it, where it would have had a much better command of the Channel: it

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behoves the Turkish Government seriously to exert every effort and means in their power to improve and strengthen these Castles, by all the power of art and science.

For if an Enemy once passes this Grand Barrier, there would remain no obstacle whatever of sufficient importance to check or prevent his accomplishing the Object of his Design, and making his way to Constantinople.

In obedience to your directions, I shall state the various defects at present existing in the four Castles and Batteries, and recommend such alterations and improvements in the Artillery Department, as would be most advisable in my opinion to be adopted for the better security and defence of the Dardanelles.

The Guns, a few excepted, appear to me unserviceable, being flawed, full of cavities, some cracked, and pieces blown out, of others.

The Metal does not appear to be of a good quality, well purified, not properly proportioned, being very brittle, and liable to constant accidents upon firing; an instance of which we were witnesses to, on the Island of Senedoes; the Guns, are most of them at present placed in front of the Great Guns or Pierriers, where in case of an attack, they would be perfectly useless. The Gun Carriages are in general too large for the Guns mounted upon them, very heavy and ill constructed for narrow Ramparts; without Beds, Quoins, Springs, Saddles, etc. The shot lay about in all directions, mixed and unpiled; are old coroded, very rugged and rough. The Magazines, I have seen, require an admission of Air, and Copper doors, otherwise are good. Powder and every description of Ordnance Stores extremely deficient.

The chief opposition, and upon which great dependance seems to be placed at present, to an Enemy's passing the Castles, are the enormous large guns or Pierriers; some of which are nearly thirty Inches in Diameter; they lay upon Skids under Archways, made in the Curtains and Bastions, cannot consequently be haversed, and only fired upon a moving object, when it happens to come opposite to their direction, it must however be allowed, that if One of these large Stone Shot, which they project, was to strike a vessel it would probably be her destruction, but as many of them break into pieces after leaving the Guns, they are of course very uncertain in their effect, and not to be alone depended upon; but as it may be advisiable to make use of them it is proposed to let them remain under the Archways, in the Curtains, next the Channel, with the alterations proposed by Major Holloway, as there may be places for them; but must observe that the principle approved and adopted of late Years, for Sea Batteries, has been to endeavour by every possible means, to move the Guns with facility by Traversing Carriages, or platforms, so as to be enabled to follow the direction of a Vessel as she sails, and to fire upon the same object as often as

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possible. A Mixture of a variety of different Natures of Ordnance, being even among the best established Artillery liable to create confusion and occasion mistakes, particularly, at a time when every precaution should be taken to guard against it, that of an attack, to avoid which, I beg leave to recommend to the Turkish Government to arm the Old and New proposed works in the four Castles, with only three kinds of ordnance; viz. 24, 18 and 12 Pounders, on Guns nearly answering to those Calibers, in the number and manner stated in the returns numbered 1, 2, 3, 4; to which I have added a list of the requisite quantity of Ordnance Stores, for each nature of Ordnance, calculating upon 150 Round shot, and 20 Case or Grape per Gun for the 24 and 18 Pounders; and 50 Round Shot, and 20 of Case or Grape for the 12 Pounders Gun.

The Guns should be mounted upon Carriages constructed on the principle of our Garrison Carriage; they will be better adapted to their narrow Ramparts, require fewer Men to serve them, and be easier worked.

Such Howitzers as are in my return proposed for the Castles, should be mounted upon proper Carriages made expressly for them:

The Ammunition proposed for them is at the rate of 200 shells per Howitzer; and the same number of shells, etc., are proposed for the Sea Service Mortar; two of which should be in each Castle.

As it is not to be supposed that these Castles, will at any time be attacked both by sea and Land together; I have regulated the proposed number of Artillery Men, by the number and nature of the heavy Ordnance, which if kept up in time of war, will I should suppose be fully adequate to the Service of the Guns on the Castles at all times.

The Number of Non-Commissioned Officers, and Gunners, required for the different Castles, and Batteries will be as follows, viz. :—

	Non-Commissioned Officers.	Gunners.	Total.
Cumealli	20	203	223
Setillahar	27	270	297
Sultania	30	334	364
Kiletbahar	15	156	171
Point de Barbier and opposite Battery	6	60	66
Equisar Battery	6	60	66
	104	1083	1187

The Number of Artillery Men and quantity of Ammunition, etc., for the Peirriers are not included in this Statement, as their exact number is not yet fixed upon.

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The next object of great importance, and strongly to be recommended for the Defence and Security of the Dardanelles, is the Establishment of a Regular Corps of Artillery for the Service of the above mentioned Ordnance, properly Officered, with a sufficient number of Non-Commissioned Officers; This corps should be well trained, in the exercises of the Guns, Howitzers, and Mortars; as well as instructed in every Branch of Artillery, necessary to make them good and expert Gunners; They should be paid and Clothed by the Government, and that regularly; Barracks or Quarters should be provided for them, and their daily rate of subsistence should be sufficient to maintain them; The pay of the Non-Commissioned Officers should be more than that of the Private or Gunner.

The Ordnance Stores should be put under the charge of a Storekeeper, who is to be answerable and accountable to the Government for the Stores; he should have a Clerk, and be allowed a sufficient number of labourers to enable him to keep the Stores in good regular order.

He should keep an exact account of all the Stores he receives, and Issues on account of the Service, and send a monthly state of them to the Government. A second person as a Check upon the Storekeeper should also be appointed, as Clerk of the Cheque, who is to have at all times free access to the Magazines and Stores; is also to keep an account of all Stores received and Issued jointly with the Storekeeper, and to report to the Government any misapplication of them that may come to his knowledge. Thirty rounds of ammunition per Gun should be kept constantly ready and lodged in Expence Magazines near the several Batteries; Kilns or Turmaus for heaving Shot should be erected.

As Iron Ordnance is infinitely preferable to Brass, and generally used in our Garrisons, being more durable and not liable to be injured by firing in the manner that Brass is; particularly if the metal is not sufficiently hard and tenacious; I therefore recommend Iron Guns for the Castles and Batteries; Should the Sublime Porte judge it prefer to adopt any part of the proposed alterations, and improvements.

About a mile and a half to the Westward of the Castle of Setillahar, is a Battery for nine Guns, in which there are at present 5 Light Field Pieces; these should be removed, and the Battery armed with heavy Guns, if it is intended that this Battery should remain; One placed on a point between it and the Castle, would answer the double purpose of forcing an Enemy's Fleet to keep a respectable Offing and be a greater protection to the Castle.

When Major Holloway has completed the plans, and projects, for the intended works in the rear of the Castles of Setillahar and Kiletbahar; I shall have the honour of laying before you some further

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Remarks, and Observations, as well as the necessary Returns of the Ordnance and Stores for them, and the Batteries.

M. HOPE.
Commanding British Royal Artillery and Major.

BRIG.-GENERAL KOEHLER.
Comdg. His Brittanic Majesty's Forces.

BOUYOUKELERE, 21st Sept. 1799.

The undermentioned Articles will be required for examining, and removing the different Natures of Ordnance in the Castles, at the Dardanelles, etc. :—

Viz. :—

Guns Complete	4
Sling Carts	2
Truck Carts	2
Sledge Carts	2
Searchers	4
Relievers	4
Prickers	4
Iron Crows	6
Crab Capstans	2
Spars	6
Skids, large	12
do. small	12
Shot Guager sets	4
Men's Harness sets	24
Coils of different sized rope	3
Blocks and Tackle	
3-in. Planks	12
Hand pikes { large / small }	24

Such Pickaxes, Shovels, etc., as may be wanted, can be borrowed from the Engineers department. I have the honour to be, Sir

M. HOPE.
Comdg. R. Artillery, and Major.

Return of the number and Nature of Ordnance for the proposed Tower and Battery, on the small Island off Tenedos :—

24 Pounders mounted on Garrison Carriages Complete	15
Stores for Ditto.	
Handspikes	60
Spunges	15
Saddles	8

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Wadhooks	8
Linstocks	8
Tampeous	15
Aprons of lead	15
Powder Horns and wires	8
Puncher for Vents	8
Spikes	15
Claw hammers	6
Shot: Round	1500
Shot: Case or Grape	300
Cartridges, Empty	1900
Wads	3800
5½ inch Shells, fixed	100
Tongs and bearers	4
Water Buckets	3
Port-fire, dozens	2
Portfire sticks	4
Powders, Barrels 90th	170
Budge Barrels	1
Powder Measured from 1st to 4th Sept.	1
Slow Match, cwts.	2
Tube	500
Tube boxes	4
Tanned Hides	2
Hair Cloths	2
Wadmill ditto	2
Lanthorns: Muscovy	2
Lanthorns: Dark	2
Sheepskins	6
Spunge Tacks	600
Tarred Marline strains	6
Guns complete	2
Portfire Clippers	4

M. HOPE.
Comdg. Royal B. Artillery, and Major.

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REVIEWS.

L'ŒUVRE ET LE PRESTIGE DE LORD KITCHENER.

(Plon-Nourrit et Cie, 8, rue Garancière, Paris).

THE Librairie Plon has recently published a brochure entitled *L'Œuvre et le Prestige de Lord Kitchener*, by M. Henry D. Davray (price 2 francs). M. Paul Cambon, the French Ambassador at the Court of St. James, in a Preface to the little volume, states that he had known the late Field Marshal for many years; since the War, he had naturally been brought into very close contact with this great Public Servant, owing to the multitudinous questions which he had had to discuss with him on behalf of his own Government. M. Cambon tells us that the relationship thus established between the distinguished Soldier-Statesman and himself disclosed to him the fact that Lord Kitchener possessed qualities of the heart which the general public little suspected in the man of cold, and almost austere, exterior, whose figure had become so familiar to them in recent years. In the degree that the dead Field Marshal was reserved and secretive in his relationship with those whose true characters were still a sealed book to him, in that same degree also was he frank and open with those who experience had taught him were worthy of his confidence.

"Lord Kitchener," says M. Cambon, "was also one of the most loyal of France's friends. He had never entertained any doubt that on the day whereon France might be threatened by an act of unjustifiable aggression, on that day she would find Great Britain ranged upon her side."

M. Davray, in the opening pages of the brochure, refers to the dismay caused in England by the sudden and tragic end of the great War Minister, to whom it is that Great Britain really owes the wonderful expansion of her "contemptible little Army" of 1914 into that giant army portions whereof are fighting in Flanders, France, Italy, Greece, Palestine and Mesopotamia to-day.

M. Davray reminds us that Lord Kitchener commenced his active military career in the French Army at a time when that Army was engaged in the defence of "*La Patrie*" against the same enemy that is assailing her to-day. Had the dead Field Marshal found a soldier's grave in one or other of the corners of the world wherein he had commanded troops, the appropriateness of such an end would have been widely recognized. Lord Kitchener, it appears, let it be understood that his own view was that he would die, under conditions of peace, quietly in his bed. Destiny had provided, however, for his exit from the field of his labours under strikingly tragic circumstances; the great soldier met with a sailor's death at a time when he was engaged on national duty of

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the highest diplomatic importance. To-day, under conditions which in their similitude resemble an anastrophe, the creator of Great Britain's most powerful Army of all time and its great Chief is at rest with a British man-of-war for his coffin ; his grave is the bed of the ocean over whose deep and wide waters Britannia's trident continues to maintain its redoubtable sway.

M. Davray very briefly sketches Lord Kitchener's wonderful career, and incidentally provides an explanation to account for the remarkable confidence placed in him by the public. In examining the circumstances under which the late Field Marshal had reached the very high station which he occupied, the man-in-the-street learnt that his Lordship's success in life lay in the possession by him of that quality which represents the exemplication of efficiency in the highest state of development ; he learnt further that his Lordship had always insisted on as high a standard of competence being attained, in their respective spheres, by his subordinates as his Lordship had demonstrated that he himself possessed. It was to an appreciation of the foregoing facts by the British Public that the immense prestige which he enjoyed may be attributed, a prestige which stood the nation in such great stead in the critical days of the autumn of 1914.

M. Davray's short account of the career of one of the most illustrious members of the Corps cannot fail to interest all Royal Engineers.

W. A. J. O'MEARA.

MATHEMATICS FOR ENGINEERS. PART I.

By W. N. ROSE, B.Sc. Eng. (Lond.).—(Pub. by Chapman and Hall, Ltd.).

THE work under review is one of the volumes of " The Directly-Useful Technical Series." In the past technical books have been written either wholly from a theoretical standpoint for the training of college students or wholly from the practical standpoint. Works falling in the first of the foregoing category have devoted attention almost entirely to problems of a purely academic character, whilst those in the second category have been concerned entirely with the presentation of data required by the technical man in his every-day work, the scientific basis upon which all good practice is built being as a rule omitted from the pages thereof. In *Mathematics for Engineers*, we have a work which occupies a midway position between the foregoing categories. The aim of the author of this work has been to provide information, and to set out problems and exercises, which shall be of a directly useful character ; the volume has been written as a work of reference for the use of the practical man rather than that of the college student, nevertheless a sufficient amount of scientific explanation has been given to elucidate the formulæ, etc., given in the volume, and the advanced student will find much information therein likely to assist him.

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It has been thought convenient to divide the subject-matter into two volumes. Part I. (the volume under review) deals with the fundamental rules and processes of Algebra, Plane Trigonometry, Mensuration and Graphs, whilst Part II. (to be published shortly) is devoted to the Calculus and its applications, Harmonic and Vector Analyses, Spherical Trigonometry, etc.

The contents of Part I. are well arranged and the subject has been developed systematically in twelve chapters, which are headed:— Aids to Calculation; Equations; Mensuration; Introduction to Graphs; Further Algebra; Plane Trigonometry; Areas of Irregular Curved Figures; Calculation of Earthwork Volumes; The Plotting of Difficult Curve Equations; The Determination of Laws; The Construction of Practical Charts; Various Algebraic Processes.

The volume is provided with a number of clear diagrams illustrative of the text. The problems worked out and the exercises set in the various chapters are all of a very practical kind and cover a wide range of engineering practice. Those who experience difficulty in readily solving problems involving factorization or requiring the manipulation of decimal fractions or the use of logarithm tables, etc., will find useful rules affording a ready means for dealing with points that may have proved a stumbling block in the past.

The use of the slide-rule, of the Amsler planimeter, the Coffin averager and other aids to mathematical calculations are fully dealt with in the volume, which concludes with Tables, comprising the following:— Trigonometric ratios; logarithms; antilogarithms; Naperian logarithms; natural sines; natural tangents; logarithmic sines, logarithmic cosines; logarithmic tangents; and exponential and hyperbolic functions.

The volume under review is a useful and valuable addition to the works on mathematics already published for the special use of the engineering profession and covers some new ground.

PAGES D'HISTOIRE, 1914—1918.

(Published by the Librairie Militaire Berger-Levrault, 5—7, Rue des Beaux-Arts, Paris).

(*Continued from R.E. Journal for August*, 1918).

The 148th volume of the above series is entitled *Le Mensonge Autrichien*, sub-title *L'incident Clemenceau-Czernin*, and therein will be found an account of the astute move made by the Central Powers to bring about, *if possible*, a rupture between Great Britain and France. Whilst the German Armies were being concentrated for their mighty effort against the military front of the Allies in Northern France, a simultaneous attempt was made to break through their political front by a peace offensive of a subtle order. The Germanic political strategists failed, however, to assess the *morale* of the French people at its true value in their calculations and suffered an ignominious defeat in consequence.

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The contents of the volume are arranged in thirteen short sections and seven appendices. The first of these sections deals with the statement made by Count Czernin, the Austro-Hungarian Foreign Minister, on the 2nd April, 1918, when addressing representatives of the Vienna Municipal Council. He is reported to have said that President Wilson might possibly be of opinion that Vienna was the most favourable soil whereon to sow the seeds of a general peace; the President might possibly think that the Austro-Hungarian monarchy had the good fortune to possess a sovereign who was sincere and honest in his desire to secure a general peace, but one who would never be guilty of committing a felony or negotiating a shameful peace; the President might also have recalled to mind that behind the Emperor and King there stood 55 millions of subjects.

President Wilson no doubt, said Czernin, recognized that this resolute mass of human beings represented a force the value whereof should not be underestimated by him. The Count next stated that there had been a misunderstanding with regard to a remark which he had made in a previous speech to the Delegation; he had then said that Mr. Wilson was already in possession of his views, but this the American President denied. Mr. Wilson had stated that no communications had passed directly between himself and the Austro-Hungarian Foreign Minister, and in this respect Czernin agreed that the American President was quite right.

Czernin proceeded to tell the City Fathers that before he delivered the speech in question proper arrangements had been made for the transmission, from a neutral country to Washington, of the correct text of what he was about to say, in order that there might be no possibility of a misunderstanding or of his speech being misreported; in order also that, at the moment when he would be speaking in Vienna, a copy of his speech should already be in Washington.

Czernin then informed his audience that, as a matter of fact, the text of his speech did not reach America till some days later; however, according to him this was of no consequence. The object he had in view, namely, that President Wilson should become cognizant with the exact text of his speech, was attained; in his opinion, the fact that a delay occurred in this copy of the speech reaching the President's hands was a matter of secondary importance.

Czernin expressed himself as satisfied with President Wilson's speech of the 11th February last and stated that the four principles laid down therein constitute an admirable basis whereon to open the discussion on the subject of a general peace. He declared that the Central Empires had done all in their power to avoid a new offensive. The Entente Powers, however, were unwilling to take advantage of this considerate attitude of the Central Empires.

"M. CLEMENCEAU, SOMETIME BEFORE THE COMMENCEMENT OF THE OFFENSIVE ON THE WESTERN FRONT, CAUSED ME TO BE SOUNDED," said Czernin, "FOR THE PURPOSE OF ASCERTAINING WHETHER I WAS PREPARED TO OPEN NEGOTIATIONS FOR PEACE AND ON WHAT BASIS. I REPLIED IMMEDIATELY, BERLIN BEING IN AGREEMENT ON THE SUBJECT, THAT I

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WAS READY TO OPEN SUCH NEGOTIATIONS, AND THE ONLY OBSTACLE TO A PEACE WITH FRANCE THAT I COULD SEE TO BE STANDING IN THE WAY WAS HER ASPIRATIONS REGARDING ALSACE-LORRAINE. A REPLY REACHED ME FROM PARIS THAT UNDER THESE CIRCUMSTANCES IT WOULD BE USELESS TO OPEN UP NEGOTIATIONS. SINCE THEN WE HAVE HAD NO CHOICE IN THE MATTER."

The formidable struggle in the West had already, said Czernin, recommenced. Austro-Hungarian and German troops were fighting side by side, as they had done in Russia, Serbia, Roumania and Italy. The armies of the Central Empires would prove to the Entente, according to the Count, that French and Italian aspirations with regard to the territories of those Empires were Utopias calling down a terrible vengeance.

The explanation of the attitude of the Entente was traceable, thought Czernin, to certain internal events in Austro-Hungary. However, come what may, the Dual Monarchy would not abandon Germany, nor was the latter likely to abandon her Ally.

Loyalty on the banks of the Danube was in no way inferior to loyalty on the banks of the Spree. Austro-Hungary had no imperialistic or annexationist aims either on her own behalf or of that of Germany; however, they both intended to march arm in arm to the bitter end for the purposes of defence, of safeguarding their national existence and of securing their future.

The peace negotiations with Russia had made the first breach in the Will to War of their enemies; this was the chink which let in the light of peace.

"Placing firm confidence in our strength in the justice of our cause," continued Czernin, "I have thus far concluded three *moderate*, nevertheless honourable, treaties of peace."

The Count further informed his audience that the enemies of the Central Empires were beginning to see that the latter wished alone to make secure the future of the Monarchy and of its Allies—and that by force of arms—this the Central Empires felt confident of being able to do and this they would do. He expressed the opinion that the annexationists were responsible for prolonging the War and that there was not much to choose between them and the defeatists.

It was necessary, said Czernin, that the enemies of the Dual Monarchy should be defeated militarily as well as from the moral point of view. After victory had been won by the contest of arms, diplomacy would have to step in to complete the work of the Army.

In the second section is recorded M. Clemenceau's first rejoinder to Czernin. On reading the Havas telegram relating to the Austria-Hungarian Foreign Minister's speech referred to above, he made the brief remark:—

COUNT CZERNIN HAS LIED!

The third section contains the text (in French) of the official note published in Vienna on the 6th April, and constitutes Czernin's first reply to M. Clemenceau.

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The note stated that, under instructions from the Austrian Foreign Minister, Count Nicholas Revertera had had several interviews in Switzerland with Commandant Armand, of the French War Office, *an intimate friend* of M. Clemenceau. At one of these interviews, held at Friburg, the question had been raised as to whether it was possible to arrive at any understanding on the subject of a basis on which the question of a general peace might be discussed between the French and Austrian Foreign Ministers or their official representatives.

Count Revertera had been instructed to mention to Commandant Armand, for M. Clemenceau's information, that Count Czernin was ready to discuss the question of peace with an accredited representative of France, the moment that the latter renounced her intentions regarding Alsace-Lorraine.

Count Revertera was furnished, according to Czernin, with a reply in M. Clemenceau's name, wherein he was informed that the latter could not accept the proposal regarding the renunciation of France's claim to the lost Provinces, and therefore it was found useless to arrange an interview for the discussion of peace proposals.

The fourth section contains the second rejoinder of the French Premier to the Austrian Foreign Minister. M. Clemenceau sent a communication to the Press on the 8th April, wherein he explained that when he succeeded to the Premiership he found that CONVERSATIONS between Revertera and Commandant Armand, *started on the initiative of Austria*, were in progress in Switzerland. He felt that he could not abruptly terminate these conversations; on the other hand, by their continuance useful information might be obtained. It was Revertera who had wished to continue the discussions; in consequence, Commandant Armand was instructed, in the presence of the Chief of his Bureau, by M. Clemenceau: "To listen, but to say nothing."

When Revertera realized that his attempts to put the halter of a German peace round France's neck were not likely to succeed he placed a note in Commandant Armand's hands on the 25th February for the purpose of making clear the character of his mission. The introductory paragraph of this note indicated that Revertera had been endeavouring TO SECURE FROM THE FRENCH GOVERNMENT peace proposals not for consideration at the Ballplatz but really at the Wilhelmstrasse. And this is the fact, the proof whereof is contained in an authentic document, the terms whereof Count Czernin dares to transpose when he says: "M. Clemenceau, sometime before the commencement of the offensive on the Western Front, caused me to be sounded for the purpose of ascertaining whether I was prepared to open negotiations for peace and on what basis."

In speaking thus, says M. Clemenceau, he has not only not told the truth, but he has also said something contrary to the truth. In France, this goes by the name of *lying*.

The note proceeds to recall how Austria had tired out the Foreign offices at Rome, Washington and in London by her solicitations in respect of a so-called separate peace, solicitations which it can now be seen had no other aim than to transfer to other necks the yoke which has been pressing so heavily on her own shoulders.

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In the fifth section is set out Count Czernin's second official note dealing with this controversy. Satisfaction is expressed therein that the *conversations* between the Austro-Hungarian and French Governments were admitted by M. Clemenceau; however, it is suggested that the statements in M. Clemenceau's note and in M. Painlevé's contribution on the subject to the *Humanité* are not, in several essential respects, in accord with the actual facts; indeed, the departure from the true facts is so great, it is said, as to render a detailed correction of the French *communiqué* necessary.

It is alleged that Count Revertera was invited, in July, 1917, by a neutral intermediary, *acting on behalf of the French Government*, to say whether he was in a position to pay attention to any overtures which France might make to Austria-Hungary. Count Revertera, being duly authorized, replied in the affirmative a few days later; in consequence, Commandant Armand, a distant relative, called on him *at his home* in Friburg on the 7th August, 1917.

Commandant Armand enquired on behalf of M. Ribot, the then Premier, whether conversations between France and Austria-Hungary could usefully take place.

The initiative in the matter, it is stated, was taken by France. Count Revertera was thereupon officially instructed to ascertain whether any proposals could be formulated on the basis of which the discussion of the question of general peace could proceed.

Count Revertera entered into *pourparlers* with Commandant Armand on the 22nd and 23rd August, 1917; and it is admitted that the result was as M. Clemenceau has stated; the negotiations at once terminated.

In his note Czernin says that M. Clemenceau is incorrect when he states that the Revertera-Armand negotiations had already begun at the time when he assumed the Premiership. It was only in January, 1918, that Commandant Armand renewed, on the direct instructions of M. Clemenceau, his official relations with Count Revertera.

It was this resumption of official intercourse between the Austrian and French representatives that gave birth to the negotiations mentioned in the official *communiqué* of the 4th April, 1918. It is admitted that Count Revertera on this occasion handed a note to Commandant Armand, the first paragraph whereof, however, alone has been quoted by M. Clemenceau.

It is claimed therefore that the statement made by Count Czernin in his speech of the 2nd April, with regard to M. Clemenceau having made the attempt, before the commencement of the offensive in the West, to ascertain whether he was ready to open up peace negotiations, and the proposed basis for the same, is strictly true. Therefore, the charge made by M. Clemenceau that Count Czernin was lying, cannot, it is said, be supported, even after making allowance for the explanations contained in the *communiqué* of the French Government.

The Austro-Hungarian Government, it is stated, has no knowledge of the solicitations as to proposals for a "separate peace"; that is to say, concerning the solicitations which are alleged to have tired out the Foreign Offices at Rome, Paris, Washington and in London.

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On the other hand, there did take place in Switzerland, it is pointed out, interviews between Count Mensdorf and General Smuts; these interviews took place on several occasions and lasted many hours. It is also suggested that a twelve month earlier than the abortive Revertera-Armand conversations an attempt of the same kind was made by a person of much higher rank than Count Revertera; Count Czernin was accommodating on that occasion too, but in this case also the negotiations failed to mature.

It is added that there would be no point in Count Czernin denying that he took the initiative, in this or that case, had he actually done so; for contrary to M. Clemenceau's views on the subject (as alleged in the note), the Count does not consider that it should be a reproach to any Government to have made an attempt to bring about an honourable peace, one that would deliver the peoples of the world from the horrors of the present conflict.

In conclusion it is stated that the important question in this controversy is not: who took the initiative? But who is it that is responsible for the failure of these conversations? The fact which stands out is that M. Clemenceau has not denied, up to the present, that he refused to enter upon the negotiations on the proposed basis that France should definitely renounce her claim to Alsace-Lorraine.

In the sixth section matters connected with M. Clemenceau's third rejoinder to Count Czernin are dealt with. It is pointed out that a "diluted" lie remains a lie for all that. The lie that Count Czernin told consisted in the statement that, some time before the German offensive, M. Clemenceau had approached him with a view to ascertaining whether he "was prepared to open negotiations for peace and on what basis."

To refute Czernin's statement M. Clemenceau quotes a passage from Count Revertera's Note to Commandant Armand; this passage shows that it was Austria that was endeavouring *to obtain from France* proposals to form a basis for peace negotiations. Count Czernin has not contested the authenticity of the Note in question.

To mask his discomfiture Czernin has attempted to saddle M. Clemenceau with the responsibility for having taken the initiative. However, he is faced with the fact that it was not till the 18th November, 1917, that M. Clemenceau was apprised of the negotiations (that is to say, the day after becoming War Minister), whereas the letter containing the information as to these negotiations is dated 10th November, 1917, and must, in consequence, have been addressed to his predecessor.

Count Armand is represented as an intimate friend of M. Clemenceau, whereas the latter had only met this officer once previously, some 15 or 20 years ago, and then only for about five minutes.

If Count Czernin really considers the matter relating to the responsibility for the initiation of the conversations of trifling importance, as he indeed states to be the case, why, it is asked, is he making so much fuss about it all? Is it to proclaim that the views of every French Government, as indeed France herself, are fixed and immutable on the question of Alsace-Lorraine? Who would have thought it necessary for Count Revertera to throw illumination on Count Czernin's mind in

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relation to a question on which the Emperor of Austria had himself said the last word?

IT WAS THE EMPEROR CHARLES WHO, IN A LETTER DATED MARCH, 1917, BY HIS OWN HAND SIGNIFIED HIS ADHESION TO THE "JUST CLAIMS OF FRANCE CONCERNING ALSACE-LORRAINE." AND IN A SECOND IMPERIAL LETTER THE EMPEROR ANNOUNCED THAT HE WAS "IN AGREEMENT WITH HIS MINISTER" ON THE SUBJECT.

No alternative to the acceptance of M. Clemenceau's denial was ever open to Count Czernin.

In the seventh section is set out the text of the telegram sent by Charles I. to William II. This text was published in Vienna in an official *communiqué* on the 11th April, 1918.

The Austrian Emperor alleges in his communication to his august cousin that the French Premier, "driven into a corner," was seeking to escape from the tissues of lies into which he had himself, says H.I.M., packed more and more misstatements and had not hesitated to put forward an absolutely false and incorrect allegation to the effect that His Imperial Majesty had recognized as just the claims which France was making with regard to the restitution of Alsace-Lorraine.

"I repudiate this assertion with indignation," telegraphs Charles I. "At a time when Austro-Hungarian artillery is in action with German artillery on the Western Front against a common target, it is scarcely necessary for me to provide proof that I am fighting for Your Provinces and that I am ready to fight on just the same as if it were necessary for me to defend my own Country."

The Austrian Emperor considers that his conduct in supporting the German Arms affords a sufficient testimony of his loyalty to the German Emperor's cause, and he holds that it would be "*useless waste of time to devote even a single word to the lying statements of M. Clemenceau.*" (sic.). He once more assures William II. of the perfect solidarity which exists between them and between their Empires; no intrigue can put in danger their *fraternity in arms*. He concludes: "Together, we shall force an honourable peace on our adversaries."

In the eighth section is set out the text of an official *communiqué* dated 11th April, being the third of the Notes on the subject issued by Count Czernin. Therein it is alleged that M. Clemenceau was continuing to distort facts in order to extricate himself from the painful position in which he had placed himself.

Count Czernin, in his Note, held it to be useless to prove each particular misstatement alleged to have been made by M. Clemenceau. He charged M. Clemenceau with an attempt to divert attention from the real issues of the controversy; the issues being, firstly, that M. Clemenceau had, before the German offensive on the Western Front, sought a *rapprochement* with Austria-Hungary, and, secondly, that he had made it known that France could not, as a condition precedent to the discussion of peace terms, abandon her claim to Alsace-Lorraine.

To this end, says Czernin, M. Clemenceau had tried to divert attention to political proposals alleged to have been made by the Austrian Emperor in a certain letter on the subject of the restitution of Alsace-Lorraine to

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France, and he had even asserted that the Austro-Hungarian Foreign Minister held the same opinions as his Sovereign on this question.

"The absurdity of such a statement," continues Czernin, "is self-evident. It is in flat contradiction to everything that the responsible Foreign Minister (*i.e.* Czernin) has at all times stated in public, views which are well-known in France."

The Count asserts that M. Clemenceau's version of the proposals contained in the letter of the Emperor Charles consists of lies from beginning to end. What is made clear, says Czernin, is that the War on the Western Front is continuing because France desires to *conquer* Alsace-Lorraine; M. Clemenceau, therefore, could not have provided, he continues, a better proof of the fact that the Central Empires are fighting to defend their possessions.

The ninth section contains the evidence in the hands of the French Government upon which M. Clemenceau founded his statement as to the views of the Austrian Emperor on the subject of Alsace-Lorraine; it consists of an autograph letter which Prince Sixte de Bourbon received from his brother-in-law, Charles I. The Prince communicated the contents of the letter in question, on the 31st March, 1917, to President Poincaré who, with the Prince's consent, immediately made the same known to the French Premier.

The Austrian Emperor begins his letter by deploring all the misery brought into the world by the War, which, at the time of writing, was approaching the completion of its third year. He states that his subjects were united on the question of maintaining the integrity of the Dual Monarchy at all costs, and he also referred to the successes of the Austro-Hungarian Army in the Balkan theatre of operations.

He proceeded to compliment France on the powerful "resistance and the magnificent spirit" shown by her in the struggle, and gave expression to the sentiments of admiration felt by his people towards the French Army in acknowledgment of the traditional and conspicuous bravery shown by it, and towards the French people in acknowledgment of the spirit of self-sacrifice exhibited by it.

Charles I. continued: "It is also particularly agreeable to me to observe that, although temporarily foes, no real divergence in views or in aims separate my Empire from France; my sincere sympathy for France, together with the knowledge that the feelings throughout the Dual Monarchy are similar to my own, lead me to hope that it will be possible in the future altogether to avoid a return to such a state of affairs as that brought about by the present War, a situation for which I am in no way responsible. For this purpose and in order to demonstrate, in some precise manner, my sincerity in giving expression to the foregoing sentiments, *I ask you to inform M. Poincaré, the President of the French Republic, secretly and unofficially, that I will support by every means in my power, and by using all my personal influence with my Allies, the just claims of France to the restoration of Alsace-Lorraine.*"

Dealing with Belgium, the Austrian Emperor declared that "her sovereignty must be entirely restored to her, and that she must be allowed to retain her African possessions, without prejudice to the compensation she must receive in respect of all the injuries suffered by her."

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Serbia also, he stated, will have her sovereign rights restored to her; and, as earnest of Austria's good intentions towards this country, "we are disposed," he continued, "to secure for her suitable and proper access to the Adriatic Sea as well as wide economic concessions." In return Serbia will be required, as a condition precedent, to guarantee that all societies or groups, and in particular the Narodna Obrana, whose political aims are antagonistic to the Unity of the Dual Monarchy shall be suppressed and kept in effective check.

Charles I. excused himself from discussing questions affecting Russia, owing to the state of affairs in that country at the time of writing; Russia was then without any definite or legal form of Government.

The Austrian Emperor requested his brother-in-law in his turn, as a *quid pro quo*, to furnish him with his views on the subject of the relations between Great Britain and France, in order that some common ground might be found for opening official *pourparlers* likely to lead to a permanent peace; thus could be put an end to the sufferings of many millions of men and to the anxieties of innumerable families, who had already experienced much sadness.

The text of the Austrian Emperor's letter is accompanied by a Note from the French Premier, wherein the latter states that *Count Czernin having referred in his Note of the 8th April to the negotiations due to a person "of much higher rank than his own,"* the Austrian Government had now materials placed at its disposal which might permit it to give its explanation in relation to the *attempted* negotiations, the existence of which had been admitted, and to make known the details of the interviews in which its delegate took part.

This constituted M. Clemenceau's fourth rejoinder to Count Czernin.

In the tenth section appears the text (in French) of the fourth Note from the Ballplatz; it reached France *viâ* Basle on the 13th April. Therein, it is stated, that the Austrian Emperor's letter published by the French Premier on the 12th April was spurious.

The Austrian Note stated that the allusion made in the *French communiqué of the 7th April* to "a person occupying a much higher rank than the Foreign Minister" (*i.e.* Count Czernin), did not refer to the Emperor, but to Prince Sixte of Bourbon. "The Prince was occupied," the Note continued, "in the Spring of 1917, in bringing about a *rapprochement* between the belligerents."

It is definitely asserted that the Austrian Emperor's letter to Prince Sixte of Bourbon was "a purely personal and private letter, which contained *no order* to the Prince to open up negotiations with the President of the French Republic, or otherwise to transmit the information therein contained to him or to provoke or to receive any counter-statements."

The Emperor's letter, it is stated, made no mention of Belgium; further, the reference to Alsace-Lorraine therein was as follows:—"*I would have used all my personal influence to further French views, and would have supported the French claims to Alsace-Lorraine had the same been just, but they are not.*"

"It is significant," said the Note, "that the French *communiqué* passes over in silence another letter from the Emperor, mentioned in the

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French Premier's *communiqué*, and in which H.I.M. is said to have made the statement that he was 'in agreement with his minister' on the subject."

The eleventh section contains the text of the second telegram sent by Charles I. to William II.; it was received in France *viâ* Basle on the 15th April.

"The accusations of M. Clemenceau against me," telegraphed the Austrian Emperor, "are so mean that I do not propose to continue the discussion on the subject with France any longer."

"Our guns, in the West, constitute our ultimate reply."

The twelfth section is devoted to M. Clemenceau's reply (the fifth of the series). "There are some rotten consciences," he said. "Finding it impossible to save face, the Emperor Charles is stammering away in the style of the man who has been found out."

"He has been driven into accusing his brother-in-law of forgery, in having fabricated with his own hand a lying document."

M. Clemenceau explained that the original document, whereof the French Government had published the text, was communicated in the presence of M. Jules Cambon, the Secretary-General in the Ministry of Foreign Affairs, to the President of the French Republic.

It is pertinently asked whether it can be conceived as possible that the President of the French Republic would have received Prince Sixte de Bourbon a second time, on the initiative of Austria, had he been the bearer of a document contesting rather than affirming the claims of France?

The Prince, it is stated, himself showed the Emperor's letter to the members of the French Government. Moreover, two friends of the Prince are prepared to attest to the authenticity of the letter; it was given to one of them to copy out.

In the thirteenth section are set out the concluding incidents of this strange episode:—

(*a*). On the 15th April information reached France *viâ* Geneva that Count Czernin had tendered his resignation, which the Emperor had notified his willingness to receive.

(*b*). On the 18th *idem* the text of the letter from the Emperor Charles to Count Czernin (published in the *Wiener Zeitung*) reached France *viâ* Basle.

In this letter the Emperor notified Count Czernin that he was appointing Baron Burian, Minister for Foreign Affairs.

Count Czernin received fulsome thanks for his services to the Hapsburg House and to the Empire during one of the most important epochs of history. The Emperor at the same time conferred upon him the Grand Cross of the St. Stephen set in brilliants and assured him of the cordial feelings which he continued to entertain towards him.

(*c*). In spite of the apparent serenity with which Berlin and Vienna accepted M. Clemenceau's exposure of the Vienna manœuvres, and in spite of the categorical denials of the Ballplatz, the resignation of Count Czernin was accepted by everyone as an admission of the truth and accuracy of the revelations.

The Ballplatz was evidently embarrassed on discovering that the

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effect of its repudiations in connection with the now famous letter of Charles I. was to cast a stigma on Prince Sixte de Bourbon ; the repudiations amounted to a charge of forgery directed against him at the instance of the Austrian Court.

In consequence, it was felt necessary to issue a fifth Note on the subject. Therein it is stated that the latest explanations of M. Clemenceau in no way altered the truth contained in the official statements of the Austro-Hungarian Foreign Minister. The character of Prince Sixte de Bourbon was too well-known to the Emperor, it was said, to admit of any possibility of the idea being entertained that he had tampered with or falsified the Emperor's letter to him. Indeed neither the Prince, nor any one else had been accused of such an act. Since it was not possible to trace the circumstances under which a *spurious letter had been substituted for the one actually sent by the Emperor, the incident was to be considered as closed.*

The special correspondent of the *Berliner Tageblatt* in Vienna, in a communication to his paper, gave some information as to the steps taken by the Austrian Foreign Minister to disseminate his official explanation relating to the Emperor's letters.

On the 12th April, Count Czernin sent out a circular to his subordinates informing them that the allegations of M. Clemenceau concerning the Emperor's letter were " pure invention," and they were directed to give as wide a currency as possible to this statement. He added that, in diplomatic circles, a view prevailed that M. Clemenceau might meet the repudiations of Vienna by publishing the facsimile of the *alleged* letter ; in anticipation of the adoption of this course, it was given out, at the same time, that *the facsimile would be a forgery !*

The first appendix contains the statement made by M. Painlevé on the 8th April, 1918, wherein he made it known that during 1917, Austria had made several attempts to enter into official *conversations* with representatives of the Entente.

The second appendix contains the text of the telegram sent by William II. to Charles I., wherein the former acknowledged the telegram from the latter containing the repudiation of the views attributed to him on the subject of Alsace-Lorraine by the French Premier.

The third appendix contains the text of the telegram sent by William II. to Czernin. Therein, H.I.M. thanked the Count for the assistance which he had given to Germany's cause and notified Czernin that he had conferred the Iron Cross, 1st Class, on him.

The fourth appendix contains the text of a letter addressed by Charles I. to the Hungarian Parliament, wherein the Emperor's letter to Prince Sixte of Bourbon and Count Czernin's resignation are dealt with. It was stated in the letter in question that recent events did not in any way imply a change in foreign policy.

The fifth appendix deals with the decision arrived at by the French Government on the 11th April, 1918, to appoint a Commission to investigate the documents composing the *dossier* Prince Sixte and the *dossier* Armand-Revertęra.

The sixth appendix deals with the Resolution passed on the 8th May, 1918, by the Commission appointed to investigate the *dossiers* mentioned

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in the preceding appendix. The Resolution was drawn up in the following terms :—" The Commission in Foreign Affairs, having examined the documents submitted to it and having taken evidence on the subject of the conversations instituted and proceeded with at the instance of Austria-Hungary in 1917 and 1918, records its opinion that these conversations have at no time afforded an opportunity for proceeding to the discussion of peace terms likely to be acceptable to France and her Allies."

The seventh appendix contains a number of extracts from the Neutral and Enemy Press on the subject of the Clemenceau-Czernin controversy.

The 149th number contains the Official Communiqué issued by the Central Government to the Provincial Authorities of France during the period October—December, 1917 ; it is the XXXV. Volume of the series dealing with this subject. It is provided with Appendices, which deal with the visit of the President of the French Republic to Lorient in October, 1917 ; the meeting of the Presidents of the French and Portuguese Republics at Verdun in October, 1917 ; the visit of these two Presidents to Rheims on their return journey from Verdun to Paris ; the telegrams exchanged between the two Presidents, on the termination of M. Bernardino Machado's official visit to the M. Poincaré ; the reception by the President of the French Republic of the Mission from Roumanian Universities ; the address presented by the women of Oherville-en-Caux to M. Clemenceau and the latter's reply thereto.

On the occasion of his visit to Lorient, M. Poincaré presented the Legion of Honour and the *médaille militaire* to many of France's naval heroes. Addressing those present, the President of the French Republic expressed the pleasure which he felt in conveying the thanks of the country to its gallant defenders. He regretted that his official duties had not permitted him to spend as much time with France's naval forces as he would have wished. He recalled that he was in the Baltic, on a French man-of-war, at the time Austria launched her exacting ultimatum to Serbia ; and spoke of the splendid spirit which animated the officers and men of the French Navy.

M. Poincaré briefly passed in review the great work done by the French Navy and Mercantile Marine, by Dreadnoughts, by cruisers, by torpedo-boats, by patrol-boats, by submarines, by military transport vessels and by cargo-boats. He spoke of the magnificent courage shown by all grades and classes of seamen ; the contempt for danger ; the devotion and spirit of self-sacrifice exhibited by French sailors in their daily and nightly contests, in the Mediterranean and on the wide oceans, with the German U boats, the modern pirates.

Specific reference was made to the conduct of the Captain, the officers and crew of the *Kléber* of Cancale, when attacked on the 7th September, 1917, by a German submarine. The Captain and the second officer were killed on this occasion, and the command of the vessel devolved on Quartermaster Monier, who so distinguished himself as to win the Legion of Honour, presented him that day by M. Poincaré.

The address of the women of Oherville-en-Caux to the French Premier was a personal tribute to a Great Patriot, who is justly admired by the

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It remains to this day a mystery how it was that the formidable artillery, which the Germans brought against the Meuse forts, did not more quickly crush the Belgian defence on the frontier, especially in view of the disparity in the armament of the contending forces in 1914.

Since the early days of the War the Belgians have picked up a great deal of lee-way and now, in 1918, are well provided with every kind of appliance, tools, armament and equipment necessary for defence. The year last mentioned is that in which the New Military Law of 1913 would, it was expected, have provided Belgium with the full establishment of 350,000 men sanctioned by her Parliament; an army of the size which, she hoped, would enable her to fulfill all her duties as a Neutral.

Official documents published by the Belgian Government show that the strength of the Belgian Field Army was, on the 4th August, 1914, as follows:—

Formation.	No. of Rifles.	No. of Sabres.	Cyclists.	No of M.G.'s.	No. of Guns.
1st Division ...	14,000	500		18	48
2nd Division ...	14,000	500		18	48
3rd Division ...	18,500	500		24	60
4th Division ...	18,500	500		24	60
5th Division ...	14,000	500		18	48
6th Division ...	14,000	500		18	60
Cavalry Division ...		2,500	450		12
Totals ...	93,000	5,500	450	120	336

The Belgian Army was disposed on the evening of the 3rd August, 1914, to meet the eventuality of Belgium remaining neutral during the then coming conflict.

The 1st Division was concentrated at Ghent, *i.e.*, facing Great Britain.

The 4th Division at Namur and the 5th Division at Mons, *i.e.*, facing France.

The 3rd Division at Liège, *i.e.*, facing Germany.

The 6th Division and the Cavalry Division at Brussels, forming a General Reserve ready to move forward rapidly to reinforce any of the other Divisions.

Matériel.—The only type of field gun which was in possession of the Belgian Army at the outbreak of the War was that known as the 7.5 (T.R.).

A description of this gun, its sighting, its carriage and its ammunition are given in the original article.

The design of the gun and carriage were simple and both gun and carriage were constructed with an ample margin of strength. The piece was easy to bring into position, and to handle when in action. It was, of course, outmatched by the Krupp artillery brought against it by the Germans.

The artillery in the hands of Belgian gunners of to-day is something quite different to that concerning which details are published in the original article; it is not only greater in quantity, but it is also heavier, of larger calibres, and possesses a greater range. Belgian officers and men often say that had their Army been in possession of artillery, similar

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in numbers, calibre and range, to that which it is provided with to-day, the Germans could never have crossed the Meuse.

It is much to the credit of the artillery experts of the Belgian Army that, in spite of the extreme difficulties with which they have had to contend, they have nevertheless accomplished what they have in furnishing their army with weapons in every way capable of meeting the requirements of the situation.

The author of the original article calls attention to Major Willy Breton's *Etablissements d'artillerie belges pendant la guerre* wherein is described the part played by the Belgian Artillery in the early phases of the War.

The Belgians have always aimed at being a self-contained nation and, in consequence, they had provided themselves with factories and workshops, wherein they made their own guns, ammunition, etc. In December, 1915, a terrible catastrophe occurred at Graville, which was literally flattened out; not a wall was left standing, not a human creature remained alive. This was enough to discourage the stoutest-hearted of men, nevertheless the Belgians set to work to make good the deficiency thus caused.

The Belgians have since then set up munition works in the British Isles, and are now supplying not only themselves but also the British Army therefrom. In their factories the Belgians are making many kinds of precision appliances: gun sights, optical instruments, binoculars, physical apparatus, surveying instruments, altitude apparatus, alidades, goniometers, periscopes, compasses, etc., etc.

Personnel.—Officers.—In normal times, the officers of the Belgian Artillery were all educated at the *École Militaire*, admission to which was regulated by examinations in literary and scientific subjects.

After two years, at the above institution (where the discipline was very strict) the future artillery officers passed on to the *École d'application militaire* at Brussels, for a further two and a-half years. At the *École d'application* they received instruction in specialized subjects. Young men educated at the latter School were not bound to adopt a military career; those who wished to do so were allowed to adopt a Civil career, some of them, as a matter of fact, choose the profession of a Civil Engineer. The students of the *École d'application* were accorded privileges similar to those enjoyed by young men who had gained an Engineering diploma at a Belgian University. General de Tilly, the author of the well-known work on Geometry; General Brialmont, the designer of the original fortifications of Antwerp and of the Meuse defences; and General Leman, the gallant defender of Liège in 1914, are numbered among the distinguished alumni of the *École d'application.*

It was customary for a certain number of the artillery officers, after leaving the *École d'application*, to spend some time at the Cavalry School; but just before the outbreak of the present War the *École d'équitation* for the artillery had been removed to Brasschaet.

A few artillery officers, destined for employment on the General Staff, passed in due course to the *École de guerre*; it is said, that many artillery officers declined the invitation to qualify for the Staff, a marked preference being shown for a regimental career by officers of this arm.

Every year artillery officers spent a short time at the *Polygone* de

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Brasschaet for range practice, annual training, etc. Triennially, sometimes at shorter intervals, the artillery took part in the Great Manœuvres carried out by the Belgian Army.

The necessities of War have compelled the old order to give way to a new in Belgium as in this country. A special school was organized, known as the "*Centre d'instruction de sous-lieutenants auxiliaires d'artillerie*," early in the War, and placed under the direction of a competent chief, who was assisted by a few specially selected officers. The task was assigned them of training officers for the artillery as rapidly as possible. More recently a "*Centre préparatoire à la sous-lieutenance auxiliaire d'artillerie*" has been formed where young men of superior education receive preliminary instruction before being drafted to the first-mentioned Centre. The training given at the "*Centre d'instruction de sous-lieutenants auxiliaires d'artillerie*" is essentially practical in nature and lasts about four months. On completion of the course at this Centre, the young fellows are sent on to the front with the title of "*adjutant candidat-officier*" to complete their training and are attached for some months to a Section Commander.

Two "*Écoles de perfectionnement*" have also been brought into existence; one for the instruction of Section Commanders and the other for that of Battery Commanders. The latest technical developments (theoretical and practical), are studied at these schools, as well as new methods of handling artillery, etc.; lectures are also given in relation to events in progress, so far as they concern ballistics, new artillery appliances, etc., and work involving invention is also carried out at these schools.

The training of the young Belgian artillery officer is such as to continue the high scientific standard of education aimed at in the artillery arm prior to the outbreak of War and to ensure that he shall be acquainted with the latest developments of his branch of the Service.

N.C.O.'s and Men.—Prior to the War, the Belgian artillery was recruited, to some extent, from the men who volunteered for this branch of the service; but they had to come up to the physical standard required. The normal period of service with the Colours was, in those days, 26 months.

The most intelligent of the militiamen, on passing an examination, became eligible to attend the courses of instruction at the "*École de brigadiers.*" After a six months' course in interior economy, artillery material, etc., at this School the best of the students were selected for further instruction at the "*École de sous-officiers.*" The duration of the course at the "*École de sous-officiers*" was six months, on the completion of which the students were promoted to the rank of quartermaster; those adopting a military career proceeded by regular steps to the position of "adjutant chef de Section."

The War has necessarily brought about the abandonment of the foregoing elaborate scheme for the training of N.C.O.'s. When the formation of new units of field artillery was taken in hand, the authorities resorted to three sources for filling up the *cadres*.

(*a*) The men of the Garrison Artillery who had been manning the forts were incorporated into the field artillery, *i.e.*, after the capture of these works by the Germans; (*b*) the older men and the married men, recruited under the Law passed after the outbreak of War, were posted to

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the field artillery and (*c*) so were wounded infantrymen, who, owing to the nature of their injuries though not capable of doing infantry work were yet fit to man guns, etc.

In the beginning of 1915 a "*Centre d'instruction d'artillerie*" was formed, and artillery recruits were posted thereto for a two months' course.

Horses.—Before the War the Belgian field artillery was provided with a sufficient number of horses of a good stamp; they were obtained mostly from Ireland and the Ardennes.

The riding horses generally and the draught horses of the Field Artillery were Irish, but the country-breds of the Ardennes were preferred for draught purposes in the Horse Artillery.

At the time that the retreat from Antwerp began, the waste of War began to be felt and there was a considerable shortage of animals, so much so indeed as to make it necessary for the military authorities to requisition the magnificent cart-horses, which were one of the prides of Antwerp.

In the early days of the War, the horses were overworked and passed a precarious existence, being often without protection from the rain and wind. Much has been done since then in connection with the care of horses. Veterinary hospitals have been formed for the treatment of slightly wounded animals; new types of harness have been designed and manufactured, etc., etc.

The wastage has to a great extent been made good by importation of animals from the New World. A "*Centre d'instruction*" has been established for breaking in and training these animals and for giving them a rest after their sea-voyage and also to admit of their becoming acclimatized.

Uniform.—The peace-time uniforms continued to be worn by the Belgian artillery till 1915, when, with considerable regret, this arm of the service had to take into wear the now almost universal khaki-coloured garments worn by the belligerents. The artillery khaki-uniform is distinguishable from that of the infantry by the blue piping and blue tabs worn on the collar of the jacket; the Belgian infantry garments have a red piping and red tabs on the collar.—(*To be continued*).

Notes and News.

Switzerland.—The announcement is made of the death of Colonel F. de Tscharner, which occurred in June last. The deceased officer was at one time Commandant of Artillery at St. Gothard and also served on the Staff.

Colonel Schmid, Commanding the 4th (Swiss) Division, has resigned his appointment; he is succeeded by Colonel Sonderegger, who has been recently serving on the General Staff.

A new spirit is showing itself in the Swiss Army. Officers on the Active List are expressing their opinions on the War in the Swiss Press openly, and are also showing the direction in which their sympathies lie, without suffering ostracism in consequence. This is contributing indirectly, it is said, to the re-establishment of contact between the army and the people.

A better understanding between these two sections of the Swiss people is also being directly promoted owing to journalists being permitted to

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communicate to the Press military information, which they have now been authorized to obtain.

Divisional camps of instruction have been formed at various centres; the detailed information concerning military life in these camps published in the Press have caused considerable interest to be taken by the civilian population in the doings of the Army.

The question of the neutrality of Switzerland is revived. Two facts are responsible for the subject being reopened, viz.:—(*a*) The initial successes of the German offensive in France, and (*b*) the attitude of the German negotiators who recently discussed the terms of a Germano-Swiss Convention at Berne.

It is said that, even in the most Germanophil of Helvetic Centres, there was not a single Swiss, who, during these negotiations, did not feel that his country was menaced by a Teuton domination. The German proposals have apparently caused considerable uneasiness among high placed Swiss politicians; it is not so much what is contained in these propositions as the attitude shown by Germany that is responsible for the greatest alarm. Dangers lurk, it is pointed out, in neutrality; the initial adoption of such an attitude often leads to a Neutral Power subsequently intervening in a War at a time when it is too late for it to defend itself effectively.

Russia, it is suggested, has gained nothing by accepting the principle of neutrality; indeed, it has lost everything, for to-day it is completely dominated by Germany. If Russia should wish to emancipate herself now from the octopus-like grip of her Western neighbour, she could only do so by resuming the War; she is, as a matter of fact, in too enfeebled a state to resume hostilities, and any effort of hers just now would only be in the nature of a "*stratégie des petits paquets.*"

Italy, on the other hand, recognized that continued neutrality on her part might indirectly tend to promote the triumph of the Central Empires and thereby her own sovereignty might be compromised. She decided, in consequence, to abandon her attitude of neutrality before the Austro-Germans had acquired too great strength by their victories. In this she showed her prescience and her wisdom.

The question is asked: Ought Switzerland to have decided likewise? It is felt that, in view of the opinions to which Pan-Germanists have given expression in the public Press, there is little doubt what will be the fate of Switzerland should the Central Empires emerge victorious from the present struggle; these Empires have declared War on small States as well as on the great States. The answer given indirectly to the question amounts to "Yes."

Portugal.—A special correspondent furnishes a few notes on the experiences of the Portuguese troops in Flanders. The Germans made an attempt, during the early part of March last, to pierce the portion of front held by the Portuguese, but their attacks were repulsed; the Portuguese not only held on to their trenches, but also succeeded in taking quite a number of prisoners. This fact has naturally caused some elation in Portugal.

This number of the *Revue* concludes with a *Bulletin Bibliographique.*

W. A. J. O'MEARA.

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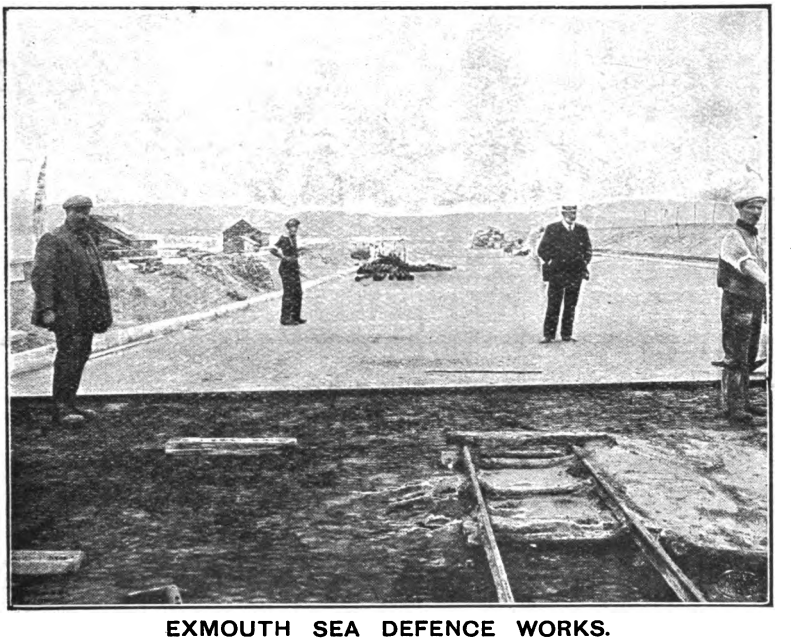

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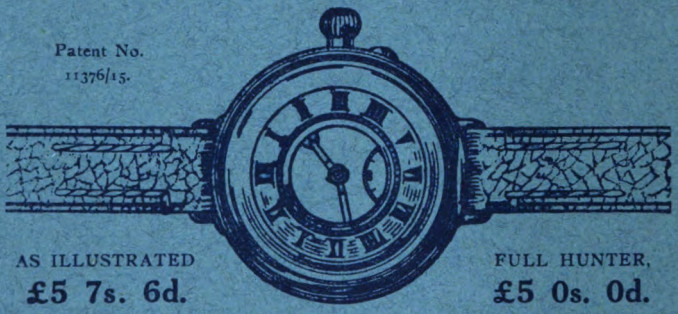

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GIRDER BRIDGES.

FURTHER NOTES ON THE DISTRIBUTION OF HEAVY LOADS.

By LIEUT. W. N. THOMAS, R.E.

A FEW notes on this subject were given in the March issue of this *Journal*, but they dealt only with the case of a 6-in. gun passing over a bridge 10 ft. wide between the ribbands, and 10 ft. from centre to centre of the outside girders.

The present paper which deals with a different load, viz. a loaded 3-ton A.S.C. lorry, is intended to supplement the paper previously submitted, as one or two points of interest can be shown more clearly under the conditions here assumed. For instance, the width from outside to outside of the lorry wheel tyres is 6 ft. 5 in., so that the eccentricity of loading may vary from 0 to 21½ in. on each side of the centre line of the bridge, whereas the width from outside to outside of the gun wheels is 9 ft. which allows a variation in eccentricity from 0 to 6 in. only.

The variations in the reactions on the different girders and in the bending moments on the decking, due to variations in eccentricity may accordingly be studied here in more detail and curves are given below to illustrate these.

The same notation has been adopted as in the previous paper, and as the calculations are very similar, they are not reproduced here. The load on the front axle of a loaded 3-ton lorry is 2·5 tons and that on the rear axle 5·5 tons, the length of wheel base being 14 ft. 5 in.

If a live load factor of 1½ be adopted the equivalent dead load is 3·75 tons on the front axle and 8·25 tons on the rear axle. *Fig.* 1 shows other data for the rear axle load.

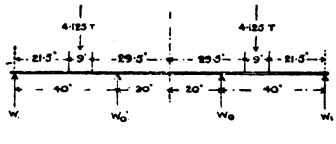

Fig 1 Equivalent Dead Load on Rear Axle.

If it is desired to adopt a live load factor of 2—and this is probably more satisfactory—the results can easily be deduced from those shown on the diagrams by multiplying by the factor ⅘.

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Reactions on Main Girders.—The full lines in *Fig.* 2 show the manner in which the rear axle loads are distributed upon the four girders of a 4-girder bridge, for different values of *c*.

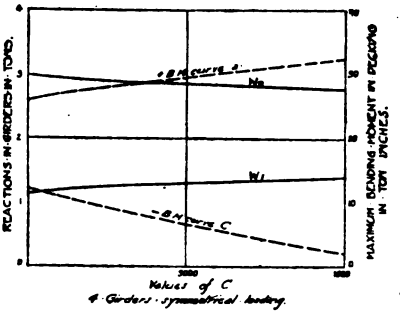

Fig. 2.

The girders are assumed to be equally spaced, and 10 ft. from centre to centre of the outer, and the load to be symmetrically placed about the central axis of the bridge as in *Fig.* 1.

The curve marked W_0 thus gives the reaction in each of the two inner girders, and that marked W_1 that on each of the two outer girders.

The full lines in *Figs.* 3 and 4, similarly give the same information when the eccentricity of the load is 10½ in. and 21½ in. respectively—in the latter case the wheel being against the right-hand ribband.

Thus W_0 is the reaction on the inner right-hand girder.

W_0^1 ,, ,, left ,, ,,

W_1 ,, outer right ,, ,,

W_1^1 ,, ,, left ,, ,,

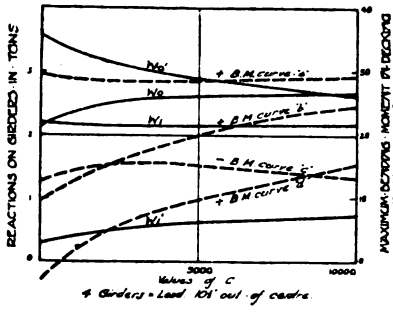

Fig 3.

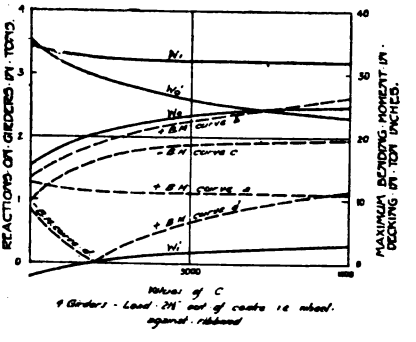
REACTIONS ON GIRDERS IN TONS
MAXIMUM BENDING MOMENT IN DECKING IN TON INCHES.
W1
W0'
W0
+ B.M. curve B
- B.M. curve C
+ B.M. curve A
+ B.M. curve D
W1'
Values of C
4 Girders - Load 21½ out of centre ie wheel against ribband

Fig 4.

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Fig. 5 is compiled from *Figs.* 2, 3, and 4, and from similar curves for other values of the eccentricity.

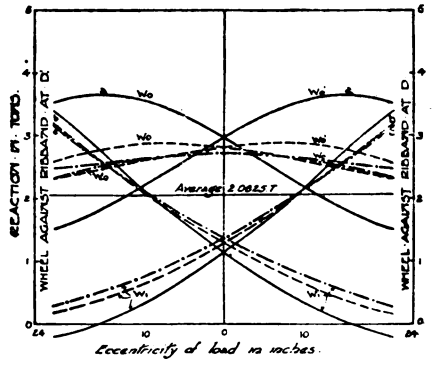

Fig. 5.

The full lines show how, when $c=0$, the reactions vary as the eccentricity of the load gradually changes from $21\frac{1}{2}$ in. to the left of the axis, through the symmetrical position, to an eccentricity of $21\frac{1}{2}$ in. to the right of the axis.

The dotted lines, and the " dot-and-dash " lines show the corresponding variations when $c=5{,}000$ and when $c=10{,}000$ respectively.

Similar curves may be drawn for other values of c, and these curves enable the maxima curves in *Fig.* 6 to be deduced.

Thus the maximum value of any full-line curve in *Fig.* 5 (*i.e.* $c=0$) is seen to be about 3·65 tons, *i.e.* at the point *a*, and this value is plotted for $c=0$ in *Fig.* 6 to give the point *a* there shown.

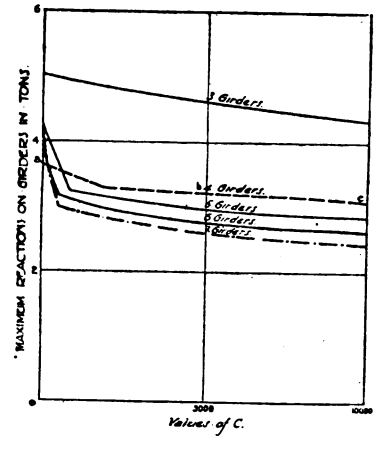

Fig. 6.

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Similarly when c=5,000, the max. value is at b (*Fig.* 5), and when c=10,000, the max. value is at c (*Fig.* 5)—in each case when the wheel is against the ribband, and these values are transferred and plotted as shown in *Fig.* 6.

Evidently then, if a sufficient number of such points are located, a curve such as that given in *Fig.* 6 may be drawn to show the maximum pressure that can occur on any of the girders of the bridge.

Fig. 6 has been constructed in this way to show the maxima curves for 3, 4, 5, 6 and 7 girder bridges respectively.

Fig. 7 is of interest as showing the factor by which the average reaction (*i.e.* $\frac{8{\cdot}25}{N}$ tons, where N is the number of girders) must be multiplied in order to determine the maximum reaction for any particular value of c.

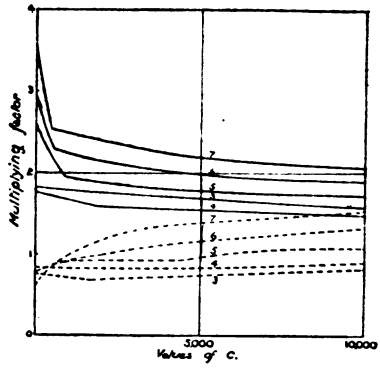

Fig 7

Thus with four girders, the average reaction is $\frac{8{\cdot}25}{4}$=2·0625 tons, while the maximum value when c=5,000 is about 3·20 tons, so that the multiplying factor for this particular case is about 1·55.

The unevenness of the distribution is seen from these diagrams to be more than is perhaps usually recognized.

Bending Moments in Decking.—The dotted lines in *Fig.* 2 show for a 4-girder bridge, the bending moments in the decking for various values of c when the load is symmetrically placed about the axis of the bridge as in *Fig.* 1. Those in *Fig.* 3 show the bending moments when the load is 10½ in. out of centre towards the right, and those in *Fig.* 4 the bending moments when the load is 21½ in. out of centre towards the right, and consequently when the right-hand wheel is against the ribband.

The curves *a* refer to the max. B.M. under the right-hand wheel.
" *b* " " " left " "
" *c* " " over the inner right-hand girder.
" *d* " " " left " "

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Fig. 8 is compiled from these and from similar curves for other values of the eccentricity of the load.

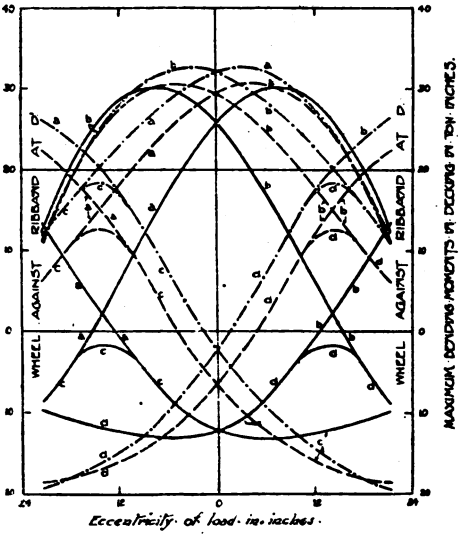

Fig. 8

The full-line curves show how for a 4-girder bridge the above curves *a*, *b*, *c*, *d*, vary as the eccentricity changes from 21½ in. to the left to 21½ in. to the right of the axis, when $c=0$.

The dotted lines give similar information when $c=5{,}000$, and the "dot-and-dash" lines when $c=10{,}000$.

From these and similar curves, the maximum values of the B.M.'s for any eccentricity and for various values of *c*, can be deduced, and plotted as in *Fig.* 9 where the curves for 3, 4, 5, 6, and 7 girders respectively are shown.

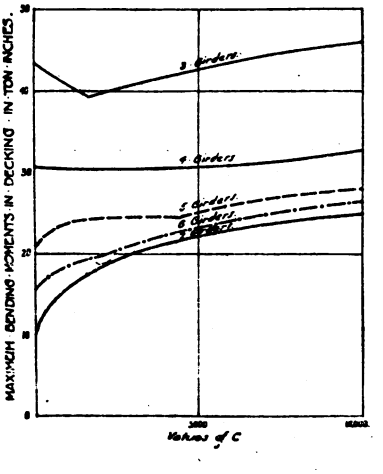

Fig. 9.

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The dotted lines in *Fig.* 7 show the factors that must be employed to obtain in any case the max. B.M. from the value obtained by calculation on the assumption that the strip of decking carrying the load, is a simply supported beam with a span equal to the distance from centre to centre of the main girders.

Example.—A bridge of 12-ft. span, and of the type under consideration is to be constructed, using 9-in. × 4-in. × 21-lb. R.S.J.'s and 10-in. × 5-in. timbers for the decking.

The max. B.M.'s, both in the girders and in the decking, will occur when the rear axle load is in the centre of the span, so that the front axle load need not be taken into consideration.

$$I \text{ for the decking} = 104{\cdot}16.$$

$$I_1 \text{ ,, girders} = 81{\cdot}1.$$

$$c = \tfrac{1}{48} \cdot \frac{L^3 E I}{E_1 I_1}$$

$$= 3{,}550 \text{ nearly.}$$

With 4 main girders the maximum load on a girder (*Fig.* 6) is about 3·20 tons, which produces a stress of about 6·4 tons per sq. in. independent of the stress produced by the dead load of the superstructure. The B.M. in the decking (*Fig.* 9) is about 30·4 ton-inches, which gives a stress in the timber of about 1,630 lbs. per sq. in.—an excessive amount.

With 5 main girders, the max. load is about 3 tons on a girder, and the stress in the steel about 6 tons per sq. in.

The max. B.M. in the decking is about 24·4 ton-inches, and the corresponding stress in the timber about 1,310 lbs. per sq. in.

At least 5 girders are required therefore, although, as the girder reactions are taken as "point" loads, the above stresses on the timber may be rather higher than would actually be the case.

Effect of Several Axle Loads.—The type of bridge under consideration is not economical for large spans and is not likely to be adopted for such, so that in all general cases, *i.e.* for spans up to about 30 ft., it is sufficient to consider only the case when the heavy axle load is in the centre of the span, as in the diagrams given above.

The accurate determination of the maximum B.M.'s on the main girders and in the decking, in the case of larger spans carrying a train of lorries, becomes very complex, and a rigid solution is not attempted here.

A few general notes however are appended.

1. The fore wheels of the lorry have only single tyres, while the rear wheels are fitted with twin tyres. The loads on the former are therefore more concentrated than those on the latter, and consequently the curves given in the preceding notes altered in proportion

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to the total axle load, are not strictly applicable to the fore wheel loads, though the discrepancies should not be very great.

2. The value of c $\left(\text{where } c=\frac{KL^3EI}{E_1I_1}\right)$ varies according to the position of the load upon the span: as already explained c diminishes and approaches the value $c=0$ as the abutments are approached. The distribution varies as c varies (*vide Fig.* 2—6) so that every wheel load on one side of the axis is transferred in a different proportion on to the supporting girders.

3. The deflections of the main girders under each load are increased by the effect of the other wheel loads; the differences in deflection are increased and the distortion of the decking under the load is increased. This is equivalent to an increase in the value of c, say from c_1 to c_2, and hence there occurs a further alteration in the distribution of the loads on the main girders. The tendency is then for the maximum reaction on a main girder to be diminished and for the B.M. in the decking to be increased; this diminution in the reactions is accompanied by a slight diminution in the deflections due to these reactions, so that part of the increase in c just mentioned is neutralized, and the final value of c is between c_1 and c_2.

It would be on the safe side then to calculate the maximum B.M.'s in the main girders from the reactions which correspond to the values of $c=c_1$; and to calculate the B.M.'s in the decking from the values of the centre reactions which occur when $c=c_2$.

TABLE I.

Span in Feet.	A	B
28 8	1	—
30	1·05	27·12
35	1·23	7·30
40	1·37	5·57
45	1·46	4·99
50	1·54	4·69

In the table above, the beam is subjected to 3 axle loads—a rear axle load in the centre of the span, and a fore axle load 14 ft. 5 in. on each side—distributed in the same proportion on the main girders.

A is then the ratio $c_2 : c_1$ under the central load.
B ,, $c_2 : c_1$,, outer loads.

I am indebted to Lance-Corpl. F. Tomkinson, R.E., for his help in preparing the diagrams.

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CONCEALMENT IN FIELD WORKS.

By C. DE L.G.

IN *Military Engineering*, Part I., Section I. (which is really the most important section of the whole book, and it should be impressed upon all young R.E. officers that, as stated in that section, it is principles of Field Works Construction which should guide him and that it is impossible to lay down hard and fast rules as to exact dimensions, shape, etc., of works in the Field as these entirely depend upon the armament of the forces engaged at the time, tactical considerations, material, labour and time available, the action of the enemy, the lie and nature of the ground and a hundred other factors), it is stated: "It is essential that in construction of works of defence the greatest precautions should be taken to ensure their concealment." As in defence concealment is essential, so it is equally in all works in the Field, especially now with the increase of air reconnaissance and aerial photography, in which the smallest detail of work can be picked out, unless very carefully concealed. And this great necessity for concealment is one of the foremost principles which must guide us in the construction of works in the Field.

But often one sees not the slightest attempt to adhere to this principle. Almost anywhere in France may be discovered important works—M.G. emplacements, headquarters, etc., made into the most appalling "cockshies." The only excuse that seems at all acceptable in many cases is that it is so obvious that the enemy would be sure to assume that it was a dummy and therefore pay no attention to it.

Now consider the purposes of paying this great attention to concealment of all works, or "camouflage" as it is better known now, and this name seems to frighten many people into thinking that it is something new and mysterious, whereas concealment of works in War is known to have been practised as far back as history carries us. The object of concealment is to prevent the enemy from knowing our dispositions either in defence or preparatory to attack. For instance, supposing when the enemy is attacking, a machine-gun, which has been kept in a carefully concealed emplacement which the enemy has not spotted and therefore has not bombarded, or registered on or neutralized by his fire, suddenly opens fire, it will cause great disorganization and loss to the attacking forces. While *vice versa*, from an obvious M.G. emplacement, even if it has 4 ft. of concrete cover,

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a machine gun will not have nearly so great an effect, partly because it will be so very unhealthy from enemy projectiles (splinters and bullets may always get through the loopholes even if a direct hit at the base of the emplacement does not destroy it) and partly because the enemy, knowing its presence will try to avoid it frontally, by means of utilizing the lie of the land, and will work round to its rear. Its importance in connection with work preparatory to attack is obvious, if any sort of surprise attack is to be effected, and the value of surprise attack has been clearly shown innumerable times during the last twelve months. Another object of concealment besides that of causing surprise is to attain security—also by hiding the dispositions of your garrison from the enemy. Thorough concealment is more protection than a great deal of cover over an obvious shelter which the enemy will keep under fire to catch the inmates emerging, For this reason too much care cannot be paid to the disposal of spoil from dugouts. In nine cases out of ten the position of dugouts can be picked out on aeroplane photographs by the mass of spoil on the parapet and parados all round the entrances to them; it is very easy to dispose of spoil without showing the position of a dugout in the very least with a little careful thinking out and organization.

The means of attaining concealment are study of surroundings, common sense and making careful plans before you start work, and discipline. The latter point is where so many fail. If care is not taken and strict discipline maintained the men employed on the work will become careless, leave their tools lying about on the site of work, walk about there showing themselves to the enemy, make innumerable tracks up to the work, all of which the enemy will spot and make him suspect that there is something there worth keeping an eye on.

In assimilating surroundings, it is obvious that natural "camouflage" is the most effective—making use of hedges, trees, houses (for concrete M.G.E.), haystacks and turnip heaps (also for M.G.E.'s), etc., all of which offer great possibilities with a little ingenuity. The difficulty comes when the work has got to be done in the open; and to assist, the camouflage service has been formed, to give advice and supply material. But this does not mean that absolute dependence should be placed on such a device. An excellent pamphlet on camouflage has been issued by G.H.Q. in France and should be studied by all R.E. officers.

It is not intended to go into details. What is wanted is some material the same colour as the surrounding ground to cover the work with—always bearing in mind that foliage changes colour with the seasons. Remember, too, that nothing is of regular shape in nature, so avoid regularity of outline, and, above all, avoid shadows. Tracks must be very carefully watched; every track, however little worn, if the grass is at all bent, shows up in an aeroplane photograph. If it

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is impossible to avoid making them or to conceal them, continue them on beyond the work. It is absolutely necessary, of course, in the case of using artificial camouflage to erect it before you start work of any sort. Owing to the deep shadow caused in them, open trenches are practically impossible to hide from the air. They can of course easily be hidden from ground observation by planting sods, etc., on the parapet. Saps can be hidden from air easily enough by stretching " scrim " (close netting) coloured the same as the surrounding country over them. To avoid giving away position of headquarters, cable trenches can very easily be concealed for some distance on each side of the headquarters by placing " scrim " over the plain earth of the filled-in trench, and making a dummy one leading off somewhere else. In a trench system, however, the great thing is to conceal the position from which big fire effect will be brought, *i.e.*, M.G.'s, L.G.'s and the positions of the shelters of your garrison; and thus keep the enemy in the dark as to your dispositions.

The broad outlines of how to tackle the application of this principle of concealment have been touched upon; the thing to aim at is " to conceal the fact that you are concealing anything " and spare no pains in effecting this by careful thinking out and using common sense. It is surely the most important principle of any in the construction of works in the Field and should be very carefully studied by all R.E. officers, who are experts in all constructions of any description and as such must be ready to give advice at any time upon anything connected with the design and execution of such works.

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DEMOLITIONS IN THE FIELD.

By C. DE L.G.

THE great majority of demolitions carried out on Active Service are done so during retirements, and to effect real delay to the enemy complete destruction only is of use. In order to obtain this completeness, the principles given in the Military Engineering text books are guides to us. Remember that explosives deteriorate, and that they are not quite so effective as supplied now as they were, and allow plenty in excess ; let your 50 per cent. be well on the large side !

But besides the calculation of the size of the charge, the method of placing and fixing the tamping, etc., there are two other considerations which must be dealt with in demolitions carried out during a retirement. Firstly, time to prepare and fix the charge ; the retirement may be going so quickly that this cannot be done, or only hurriedly done so that bridges—or whatever it may be—are left intact for the enemy to come on unhindered ; in other words, the R.E. have not done their job. Secondly, certainty that all our forces are clear before the demolition is effected, so that some are not cut off or injured, as cases have sometimes occurred.

With regard to the preparation of charges, it is suggested that all important constructions—such as main bridges, railway depôts, mines at important cross-roads—should be prepared for demolition for a considerable distance back in the War zone during periods of stationary warfare. This work should be considered just as much a necessary defence measure as the construction of defensive lines in depth. If it is not considered necessary or advisable to actually place the charges, the scheme for demolition should be made out, showing the size of charges, their placing, arrangement of leads, etc., so that actual work can be done in the minimum time. The possibility of the enemy overrunning our advanced positions quickly makes it advisable that the charges at points near the firing line shouldbe actually placed, protected from weather and ready to be detonated and blown at very short notice. In all cases the responsibility for the actual blowing should be detailed to a certain individual.

Having got the charge ready and the party detailed to carry out the demolition prepared to do so at any moment, the difficulty of knowing when to do it arises. Unless the position and activities of all troops operating in the neighbourhood are known it is extremely difficult to ascertain if all our troops are clear. The responsibility

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for the ordering of the actual demolition is therefore delegated by the General Staff to the commander of the lower formation who will have troops last to get clear. This is fairly simple in the case of an orderly rearguard action, but if the retirement is at all hurried and there may be other troops mixed up and not actually under the orders of the commander concerned, the communications may not be of the best, then it is impossible for him to know the exact position of all troops. In that case the R.E. officer who is responsible for the demolition may be badly let down by the order being given too late ; the writer knows of a case like this occurring recently, with the result that the officer lost his life and the charge was not blown, because the enemy were on top of the party before the demolition could be carried out. The only way to overcome the difficulty is for the officer of the demolition party to ascertain from the commander who has been detailed to give the order for the demolition to take place, all details of all troops known to be operating in the neighbourhood, and their probable action--" probable " because nothing definite can be foretold when troops are in contact with the enemy. Knowing this, and keeping in close liaison with the nearest headquarters as long as possible, with his charge ready to be blown any minute, the R.E. officer must then use his own judgment and initiative in deciding when to blow—it will often be just as the enemy is appearing on the scene—and get away and report the result as quickly as he can.

As so many failures to carry out demolitions have arisen from both these causes recently, it is thought that this short note may be of value ; the gist of it is that organization plays a great part--as in all R.E. work—in the execution of successful demolition.

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NOTES ON THE AIRLIFT PUMP.

By Bt. Major H. S. Briggs, R.E.

(I.). General Description.

The airlift is a device for raising water from a depth by means of compressed air. The method of operation is such that a column of water unmixed with air is opposed to a column of air and water mixed. A mixture of air and water has a lower specific gravity than that of plain water, depending on the relative volumes of air and water in the mixture. When the difference between the weights of the two columns is in favour of that of plain water, the column of mixture is set in motion, and under favourable circumstances the air and water are discharged above ground level. When the columns balance one another, no motion ensues.

Fig. 1 shows an airlift installation in diagram form. This system is known as the "Central Air Pipe System." Other systems are in use, which differ only in the arrangement of piping, but which in principle are identical.

It is evident from the diagram that the pressure of the air admitted to the water must at least be equal to the head of unmixed water above the point of entry of the air; in other words, the air pressure depends on the degree of submergence of the air pipe, and *not*, as is commonly supposed, on the height to which the water is lifted, although a certain degree of submergence is necessary to set the column in motion.

In practice the working air pressure will slightly exceed that equivalent to the external column of unmixed water, by an amount corresponding to the frictional resistance encountered during the passage of the air through the air pipe.

The "starting pressure" is almost always greater than the "working pressure" for two reasons:—First, because the standing water level is usually lowered when pumping is in progress, and secondly, on account of the extra energy required to set the column in motion.

The latter amount is approximately the equivalent of the velocity head of the moving column of water, and therefore equal to $\frac{V^2}{2g}$ ft.

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of water, where V is the velocity in ft. per second of the *water*. In most cases this amount is small and can be neglected, *e.g.*, for a flow of about 100 gals./min., in a 4-in. pipe the velocity is about 3 f.s. and the velocity head is about $\frac{9}{2\times 32.2}=0.14$ ft. of water or 0.06 lbs./sq. in.

In some cases (owing to low Submergence Ratio) difficulty has been found in overcoming the initial inertia of the system, and air connections* have been arranged so that air pressure could alternately be put on to the surface of the free water column and the bottom of the air and water mixture column, thus getting up a kind of "bounce" in the system. This method should not be necessary if the system is properly designed, and no difficulty should be found in getting the lift to start. The air should be admitted slowly until the first head is blown off, and the lift is in operation.

(II.). The Advantages of the Airlift.

The advantages of the airlift over other forms of pumps for raising water from a depth may be summarized as follows :—

(*a*). All the moving parts and machinery are on the surface of the ground and are open to inspection and proper maintenance. The expense of a breakdown is one of the most serious objections to the ordinary pattern deep-well pump, when several hundred feet of rods have to be lifted from a well.

(*b*). More water can be lifted from a borehole by an airlift than by a deep-well pump, provided the water is there.

(*c*). The pumping station can be located in any desired position, regardless of the position of the well. It follows from this that existing sources of power situated some distance from the well can often be utilized for driving the compressor.

* This necessitates sealing the top of the well between the casing and the rising main so that a pressure can be exerted in the space above the free surface of the water. Some authorities maintain that this should always be done, it being claimed that a few pounds pressure on the surface of the water while the lift is in operation tends to prevent surging of the two columns and to produce a more even flow. It is doubtful, however, if any appreciable increase of efficiency results.

In a well liable to become sand choked, and where the water is drawn in through perforated casing, it is of great advantage if the well is capped and air connections arranged as just described. If a pressure is built up periodically in the space above the rising main the water will be forced back into the feeding strata or fissures, and the sand washed away from around the casing.

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(*d*). The airlift is the only pumping system which permits of a standby plant being provided for working a borehole.
(*e*). Several wells can be driven from one plant.
(*f*). The water is often sensibly purified by the aeration to which it is subjected.
(*g*). The yield of the well is often increased.
(*h*). Sandy or gritty water can be pumped without detriment to the plant. This is one of the most fruitful causes of breakdown of deep-well pumps.
(*j*). It is not affected by frost.

The disadvantages of the system are :—

(*a*). Low thermal efficiency.
(*b*). The well should be roughly twice as deep as the working lift for moderate lifts and about one and a-half times as deep for high lifts.

(III.). Theory of the Airlift.

It has already been stated that the operating factor is the difference of pressure—or weight—of two columns, one of unmixed water, the other of air and water mixed. This pressure difference is the driving force which produces the discharge of the air and water mixture. A greater difference of pressure results in an increased delivery of water ; at least, up to a point at which frictional and other losses counterbalance an increased pressure difference. If the difference of pressure is not sufficient, no water is lifted. This fundamental axiom is frequently lost sight of, or obscurely expressed, by writers on the subject.

The action of the airlift is often ascribed to " piston-like volumes of air which, expanding, induce the flow of water " or to the " buoyancy of the air bubbles " and similar vague expressions.

It is unfortunately the case that the airlift is an apparatus in which the effects of " losses " of one sort or another are very much more pronounced than in perhaps any other hydraulic machine. The laws governing the flow of water in a pipe have been investigated with tolerably accurate results, and the same is true, though to a lesser degree, of air. The motion of a mixture of air and water in a pipe has not, however, been fully investigated, though the friction co-efficient is said to be about six times that of water alone at the same velocity (*Gibson*).

When this motion is complicated by the fact that the pressure of the air is continually decreasing and consequently, the volume of each air bubble is increasing, with a resultant tendency for the air bubbles to coalesce, the problem becomes one of considerable difficulty.

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Although a large amount of experimental work has been carried out on the subject, chiefly by manufacturers concerned in the sale of airlift pumps, there do not appear to exist any records of experiments on a really extensive scale, conducted under scientific conditions of accuracy, and under commercial conditions of application. This is unfortunate when the many advantages possessed by the airlift pump over other types of pumps are considered.

The driving force of the airlift has been defined as the pressure difference of a column of unmixed water and a column of air and water mixed.

This pressure difference will, broadly speaking, increase as the ratio* of the working submergence to working lift increases, and also, as the ratio of the volume of air to water in the mixture is increased.

The driving force varies, then, with each of two independent factors, but the utilization of the driving force to obtain delivery of the maximum amount of water for the minimum expenditure of energy, depends on the proper adjustment of the two factors referred to, viz. :—

(*a*). Submergence ratio.
(*b*). Air volume per unit volume of water delivered.

To take an extreme case, the air volume might be so increased as to fill the whole of the rising main, in which case for a given submergence ratio the driving force would be a maximum but the amount of water raised would be *nil*.

The factors governing the proportions of air to water employed, the proper adjustment of the submergence ratio, and the determination of the proportions of the rising main will be briefly discussed, but the discussion will be prefaced by a consideration of the losses involved in the system.

The magnitude and diversity of the losses involved preclude any attempt at a strict mathematical investigation into the operation of the airlift. This fact will be realized when the following sources of loss of energy are considered.

The overall losses in the system may be divided into two classes :—

(1). Loss in energy from compressor to footpiece.
(2). Losses in rising main.

The losses in Class (1) include those due to bad mechanical efficiency of the compressor plant, air friction losses in air mains and footpiece, and loss of heat of compression, but are in general small compared with the losses in the rising main.

* Submergence ratio.

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The losses in the rising main, however, are considerable, and must be considered as mutually affecting one another, although for present purposes they may be classified as follows :—

(i.). Losses during entry of the water into the rising main before admixture of air.

(ii.). "Friction" losses due to the roughness of the interior of the rising main and obstruction of bends, etc.

(iii.). "Turbulence" and eddy losses in the air and water mixture.

(iv.). "Slippage" of air bubbles through the surrounding mixture.

(v.). Losses due to surging of the air and water mixture, or "Surgence."

The determination of the mutual effect of all the above sources of loss (together with other minor losses) calls for a very large number of experiments.

The records at present available on this subject are far from complete, but the results attained are such as to encourage continued research, in view of the numerous advantages of the airlift over other pumping systems.

Considering the losses in the order enumerated above, the lines on which modern airlift pumps seek to overcome them are stated in general terms as follows :—

Losses in Air Energy.—The air pipe should not be too small, but when the central air-pipe system is employed, should not be so large as to reduce too much the mean hydraulic depth of the rising main.

The means of admission of air to the water should obstruct the air as little as possible, but must be such as to divide the air into fine streams.

Loss due to Entry of Water.—A bellmouth is often fitted at the bottom of the rising main to reduce entry losses. The length of rising main below the point of entry of the air should be as short as possible, but must be long enough to ensure that the air does not blow out outside it.

Loss due to Friction of the Air and Water Mixture.—The interior of the rising main should be as smooth as possible, and sharp bends should be avoided.

The mean hydraulic depth should be as large as possible, consistent with the limitations imposed by considerations of "slippage" and "surgence" losses. When the central air-pipe system is employed, the air pipe should be as small as possible, provided that the loss through air friction is not excessive.

Turbulence, Slippage, and Surgence.—These three effects together probably account for the major portion of the losses associated with the airlift system.

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A cluster of bubbles admitted at the lower end of the rising main will at once begin to rise, and rising will expand in volume all the way up. Opinion differs as to whether such expansion is isothermal or occurs at an equal rate from maximum pressure to atmospheric pressure at the discharge. The probability is that the expansion is irregular but is approximately isothermal.

If the motion were non-turbulent, and non-surging and if slippage did not occur, the bubbles would, if the proportions of air and water permitted, arrive at the discharge as separate volumes of air. In practice, no such action occurs; the discharge is frequently irregular, and consists of alternate volumes of air and water. According as perfection of design is reached, the discharge will be continuous and consist of a homogeneous mixture of air and water, and the residual kinetic energy of the mixture at the discharge will be a minimum.

Of the three sources of loss now under consideration that of slippage is probably the most important. It can be shown* that the slippage of an air bubble is in direct proportion to the square root of its volume. It is also evident that the effects of slippage will be the less, the greater the mean velocity of the air and water mixture.

The acceleration of the mixture is liable to be uneven from the varying frictional resistances encountered, and there is a tendency for portions of the column to break away from those below. A coalescence and expansion of air bubbles to fill the spaces between the broken portions then takes place, with a consequent falling back of the superincumbent column to correct such expansion. A surging effect is thus produced which in some cases is the cause of a great loss of energy.

The losses just enumerated may be reduced if the following conditions are observed :—

(*a*). A correct submergence ratio.
(*b*). Correct proportions of air and water.
(*c*). Correct velocity of the mixture in the rising main.

The above three considerations are dealt with in subsequent sections.

(*d*). The rising main should contain as few obstructions as possible and any necessary bends at the well head should be easy.
(*e*). The air should be introduced into the water in fine streams.

The last condition is now generally admitted to be a *sine quâ non* in efficient design.

* See " Pumping by Compressed Air," *Ivens*, p. 97 *et seq.*

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Considerations Affecting the Determination of the Correct Submergence Ratio and Proportion by Volume of Air to Water.—It is necessary to consider the above two factors together since they mutually affect the efficiency of the airlift.

Inspection of the isothermal and adiabatic compression curves will show that the energy contained in unit volume of air increases more rapidly as the final pressure is raised.

Assuming the lift to be constant, and with a given ratio of free air to water volume and a given amount of work to be done (*i.e.*, a given quantity of water to be raised) it is evident that the slippage losses are reduced as the submergence is increased. In other words the efficiency in the lower portion of the rising main, at any rate so far as losses due to slippage in that portion of the rising main are concerned, increases as the submergence ratio is increased.

On the other hand, an increased submergence ratio involves a greater length of rising main. An increased length of rising main means greater losses due to surgence, turbulence, and friction, and more important still, the rapidly expanding air in the upper portion of the rising main involves increased slippage losses.

So far as the submergence ratio is concerned, then, the efficiency will increase as the submergence ratio is increased up to a point of maximum efficiency. In the same way, for a given submergence ratio, there will be an economical proportion of air to water by volume.

The economical proportions in each case can only be gauged by the results of tests.

Fig. 4 shows the most efficient submergence ratios, as found by experiment, for various lifts (*Ivens*).

As regards the proportion of air to water the following empirical formula is good practice (*Rix & Abrams*).

$$V_a = \frac{h}{C \log \frac{H+34}{34}}.$$

Where V_a=Cubic ft. of free air per minute (piston displacement) per gallon of water.

h=Lift in ft.

C=Constant.

H=Submergence in ft.

Values of C are as follows :—

Lift.	*C.*
10 to 60 ft.	245
61 to 200 ft.	233
201 to 500 ft.	216
501 to 650 ft.	185
651 to 750 ft.	156

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The economical proportions for any particular well should be invariably adjusted by experiment, and this from the nature of the plant involved is a matter of small difficulty.

The preceding remarks have been concerned mainly with the conditions necessary for economical working. Cases arise, however, when efficiency is of secondary importance, and it is desired to lift the maximum quantity of water possible from the well.

In such cases it will be found that the delivery will increase, beyond the delivery corresponding with maximum efficiency, up to a certain point, both as the submergence ratio, and the quantity of air admitted, are increased.

Considerations Influencing the Determination of the Correct Cross Sectional Area of the Rising Main.—From the preceding discussion it is apparent that the cross sectional area of the rising main at any point, which governs the velocity of the mixture at that point must be such as to satisfy so far as is possible each of the following conflicting demands :—

(*a*). To reduce losses due to turbulence, the area should be such that the velocity is constant throughout the rising main.

(*b*). To reduce the effects of slippage, the velocity should be high, and should increase as the air in the mixture expands.

(*c*). To reduce surgence losses, the velocity should be low, and uniform.

(*d*). To reduce friction losses, the velocity should be low.

It has already been stated that slippage losses are the most important, and for this reason it would appear reasonable to allow the consideration indicated in (*b*) above to outweigh the others.

The determination of the limits within which, in actual figures, the velocity should lie, must necessarily depend on the results of practical experiment.

Authorities agree that the velocity of the air and water mixture should neither be less than 6 f.s. nor more than 25 f.s.

In a rising main of uniform cross section, owing to the expansion of the air in the mixture, the velocity will increase from bottom to top, and one of the requirements dictated by the effects of slippage will be satisfied.

In a long rising main, however, the velocity near the top may be excessive, or it may be found that an unduly long portion of the rising main may have to carry the mixture at a velocity approaching the maximum stated.

In such cases recent practice has been to make the rising main

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in two or more portions increasing in cross sectional area from the bottom upwards.

The determination of the arrangements of pipes required may be made by plotting the velocities of the mixture at points down the rising main, assuming of course an initial velocity at entry. From the velocity curve, a curve of pipe diameters may be drawn, which will represent the theoretical form of the rising main. The sizes and lengths of straight pipes can then be selected to suit as far as possible the curve thus obtained.

This method of varying the size of the rising main will not usually be required, since it will be found that with moderate lifts, deliveries, and compression ratios, that a rising main of uniform cross section will be suitable.

(IV.). The Airlift in Practice.

(*a*). *Arrangement of Piping.*—The usual methods of arranging the air pipe and rising main are as follows (see *Fig.* 3) :—

(i.). Air pipe suspended centrally within rising main.
(ii.). Air pipe outside and separate from rising main.
(iii.). Rising main suspended within air pipe.

The first method is the handiest for practical purposes, since the air pipe can readily be withdrawn or altered.

The second method possesses the advantage of leaving an uninterrupted passage for the mixture and reducing friction losses.

The third method requires other things being equal, a larger bore-hole than either of the first two methods.

(*b*). *Method of Admitting the Air to the Water.*—There are innumerable patterns of patent air pipes footpieces on the market, most of which merely serve as an obstruction to the water flow without materially increasing the efficiency.

With the central air-pipe system, the type of footpiece shown in *Fig.* 7 is recommended. It will be noted that a length of plain pipe is attached below the point of admission of the air. If this pipe is omitted, it is found that the air is apt to blow straight through the open end instead of passing through the holes in fine streams.

The length of plain pipe, while permitting scale and dirt to escape from the air pipe through the open end, secures a resisting head of water and the air taking the line of least resistance passes through the small holes.

The end of the air pipe should not be plugged as is sometimes done, since the scale and dirt from the inside of the air pipe will eventually block up the small holes.

The point of entry of the air to the water should be several feet above the bottom of the rising main to avoid any danger of the air

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blowing up between the rising main and the casing, or, where the casing is used as a rising main, between the casing and the side of the hole.

The total area of the small holes should be at least one and a-half times that of the interior of the air pipe.

A further development of the principle of splitting up the air into fine streams would be to drill a number of relatively large holes, say $\frac{3}{8}$-in. diameter, in the air pipe and cover these with fine wire gauze. This method has not, so far as is known, yet been tried, but should give good results.

The arrangement of making the air pipe separate from the rising main, with a footpiece as shown in *Fig.* 6 is probably the most efficient yet devised.

(*c*). *Arrangements at the Head of the Discharge Pipe.*—There are several methods of dealing with the discharge, three of which are shown in *Figs.* 8 to 10.

In any case, the discharge pipe conveying the air and water mixture should be as short as possible in order to reduce friction.

A long discharge pipe carrying a mixture of air and water very greatly reduces the flow of water.

Circumstances, may however, render it necessary to put in a long discharge pipe even at the expense of a considerable loss in efficiency. In one case a 4-in. pipe was used to convey the air and water mixture over half a mile but the flow which was about 8,000 gals. at the bore-hole was reduced to 3,000 gals. per hour at the end of the discharge pipe.

A method which may be employed in certain circumstances and which will result in an increased efficiency is that shown in *Fig.* 9. Here the standpipe admits of the escape of the air, while sufficient head is given to allow of the air-free water flowing down the discharge main at the required velocity.

A further development of this principle is found in the so-called "Booster" pump, in which the standpipe in *Fig.* 9 takes the form of a receiver and the air valve is replaced by an air-escape valve which can be set to blow off at any desired pressure.

The pressure remaining in the air on its arrival at the top of the rising main is made use of to force the water along the discharge pipe.

A sketch of this apparatus is shown in *Fig.* 11.

Where, however, any considerable height or length of discharge is to be encountered after the water leaves the well head, some form of surface pump should be employed to boost the water on.

The airlift at best is of low efficiency, and it is desirable to keep the working lift, both static and frictional, as low as possible.

(*d*). *Data for Design.*—The following table gives the preceding information in a summarized form.

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On this information a preliminary design may be based, due account being taken of the general principles already formulated.

Local conditions vary so much that the last degree of efficiency possible can only be obtained after successive tests on the plant installed.

No mention is made of conditions affecting compressor efficiency as these are either well known or can be found in any standard work on the subject.

(A). *Velocity of air in air pipe.* Should not exceed 30 ft. per sec., but whenever possible should be kept below 20 ft. per sec.

(B). *Admission of air to water.* Should be in fine streams, and can conveniently be through small holes not more than $\frac{1}{8}$-in. dia. The total area of the holes should be at least $1\frac{1}{2}$ times that of the main air passage.

(C). *Position of point of entry of air with reference to bottom of rising main.* 10 to 20 ft. above foot of rising main.

(D). *Ratio of volume of air to water raised.* From formula

$$V_a = \frac{h}{C \log \frac{H+34}{34}}.$$

Where V_a = Cubic ft. of free air per minute (piston displacement) per gal. of water.
h = Working lift in ft.
C = Constant.
H = Submergence in ft.

Values of "C" for various lifts are :—

10 to 60 ft.—245.
61 to 200 ft.—233.
201 to 500 ft.—216.
501 to 650 ft.—185.
651 to 750 ft.—156.

(E). *Submergence ratio.* See *Fig.* 4. (This gives "working" submergence ratio).

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(F). *Velocity of mixture.*	Not less than 6 f.s. nor more than 25 f.s. It may be necessary to enlarge the rising main from bottom upwards.
(G). *Fall of water level while pumping.*	This can only be found by test. The difference between the starting and running pressures, after correction for air friction in air pipe and $\frac{V^2}{2g}$, gives the drop in water level.

Example.—An example will show the application of the foregoing data.

Well.—6-in. borehole in chalk—300 ft. deep cased 100 ft.

Water level stands 100 ft. from surface.

Plant Available.—Compressor giving 60 ft.^{3}/min. (piston displacement) of free air at 100 lbs./in.^{2}.

It is desired to work the compressor off the shafting of a factory situated $\frac{3}{4}$ mile from the well. Ample power is available.

Delivery from Borehole.—The factory works 10 hours a day and a maximum supply of 50,000 gallons per day is required.

A reservoir can be built near the borehole which will command a gravity supply over area to be supplied, and under these circumstances the delivery pipe from the well head would be 250 ft. long with a rise of 5 ft.

The following are the calculations required :—

Air Volume.—In order to operate the compressor at its rated speed, the economical delivery of water can be found from the formula

$$V_a = \frac{h}{C \log \frac{H+34}{34}}.$$

From examination of wells in the neighbourhood the fall in water level while pumping is assumed to be about 10 ft.

Assuming lift above ground to be (with friction over 250 ft. of horizontal pipe) about 10 ft., total h is 120 ft.

From *Fig.* 4 a 64 per cent. submergence should be adopted. The running submergence in feet will then be 213 ft.

$$\therefore V_a = \frac{120}{233 \log \frac{213+34}{34}}$$

$$= 0.597 \text{ ft.}^3 \text{ free air per min. per gallon of water.}$$

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Then economical delivery of water is about $\frac{60}{0.597}$ or about 100 gals./min. This amount will be sufficient.

Air Pressures.—The maximum total air pressure will be air pressure equivalent to 223 ft. of water* + pressure due to air friction in air pipe in well + pressure due to air friction in air pipe between factory and well.

At a velocity of 20 f.s. and delivery of 60 ft.³/min. of free air compressed to about 100 lbs./in.² the smallest size pipe that should be used is a little over 1-in. dia.

Assume 1-in. air pipe in well and 1½-in. air pipe between compressor and well.

Between compressor and well (distance 3960 ft.)†

$$P_1^2 - P_2^2 = (114.7)^2 - P_2^2 = 30.48 \times 39.6 \text{ (\textit{vide table, p.} 178)}$$

$$= 1208$$

$$\therefore P_2^2 = 13120 - 1208 = 11912$$

$\therefore P_2 = 109.1$ lbs./in.² abs. or 94.4 lbs./in.² gauge pressure.

Then the air friction between compressor and well will be

5.6 lbs./in.²

For the loss in 323 ft. of 1-in. piping—

$$P_1^2 - P_2^2 = (109.1)^2 - P_2^2 = 224 \times 3.23 \text{ (\textit{vide table, p.} 178)}$$

$$\therefore P_2^2 = 11912 - 723$$

$$= 11189$$

$\therefore P_2 = 105.7$ lbs./in.² abs. or 91.0 lbs./in.² gauge.

A submergence (starting) of 223 ft. is equivalent to a pressure of 96.5 lbs./in.² and a running submergence of 213 ft. is equivalent to 92.2 lbs./in.² With pipe sizes as stated this means running the compressor at pressures of respectively 5.5 lbs./in.² (approx.)‡ and 1.2 lbs./in.² (approx.) above the rated figure for starting purposes and while running.

As, however, it is assumed that the water level is at its highest point having regard to seasonal variations, the slight overburden on the compressor can be accepted.

* Starting submergence.
† See Section VI. *seq.*
‡ Plus pressure due to starting inertia which will be small.

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The compressor may now be put down and the pipe line to the well laid.

Size of Rising Main.—Equivalent volume of 60 ft.³/min. free air at (92.2 + 14.7) = 106.9 lbs./in.² abs. pressure,—

$$= \frac{14.7}{106.9} \times 60 \text{ ft.}^3/\text{min. or } \frac{14.7}{106.9} = 0.137 \text{ ft.}^3/\text{sec.}$$

$$\text{Volume of water per sec.} = \frac{100}{60 \times 6.25}$$

$$= 0.267 \text{ ft.}^3/\text{sec.}$$

Then total volume of mixture

$$= 0.137 + 0.267 = 0.404 \text{ ft.}^3/\text{sec. at bottom of rising main.}$$

Assuming an initial velocity of 9 f.s.

$$\text{Area required} = \frac{0.404}{9} \text{ ft.}^2$$

$$= \frac{0.404 \times 144}{9} \text{ in.}^2$$

$$= 6.46 \text{ in.}^2$$

Assuming that the central air-pipe system is employed, the outside area of a 1-in. pipe is 1.33 in.²

Then inside area of rising main

$$= 1.33 + 6.46 = 7.79 \text{ in.}^2$$

The diameter of pipe to give this is between 3 in. and 3¼ in.

Assume a rising main of 3-in. uniform inside diameter be employed, this has an area of 7.068 in.², and the velocity at the bottom is consequently increased to

$$\frac{0.404 \times 144}{7.068 - 1.33} = \frac{0.404 \times 144}{5.738}$$

$$= 10.1 \text{ f.s.}$$

For the velocity at the top, the total volume is now

$$\frac{60}{60} + 0.267 = 1.267 \text{ ft.}^3/\text{sec.}$$

$$\text{and velocity} = \frac{1.267 \times 144}{5.738}$$

$$= 31.8 \text{ f.s.}$$

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This velocity is rather on the high side, so it will be advisable to enlarge slightly the rising main towards the top.

Taking the next larger size of pipe, viz. $3\frac{1}{2}$ in., this would give a velocity of

$$\frac{1.267 \times 144}{9.621 - 1.33} = \frac{1.267 \times 144}{8.291}$$

$$= 22 \text{ f.s.}$$

This is within the limit, so a $3\frac{1}{2}$-in. rising main will be adopted for a certain proportion of the depth. The next point is to determine what proportion of the length should be $3\frac{1}{2}$ in. and what proportion should be 3 in.

Fig. 12 shows velocity curves drawn for 3-in. and $3\frac{1}{2}$-in. rising mains. The most favourable point to make the change appears to be 188 ft. from the bottom. The curve drawn in firm line is the resulting velocity curve.

The step down in velocity where the change in section occurs will be a source of loss, and to lessen this, the difference in pipe sizes should certainly not be more than $\frac{1}{2}$ in. Nothing would probably be gained by inserting a tapered junction piece.

The well can now be piped up, the bottom of the air pipe, etc., being arranged as in *Fig.* 7, and final adjustment of submergence made when the actual drop of water level has been ascertained.

Discharge from Well.—Some arrangement as in *Fig.* 9 can be adopted to lead the water to the reservoir.

For the height of the stand pipe,—

Assume a 4-in. surface line, with no elbows.

Friction head	= 3.61	
$\frac{V^2}{2g}$	= 0.14	
Static head	= 5.00	
Total	8.75	
Allow for air space at top	= 3.25	
Height of stand pipe	=12.00 ft.	

In designing an airlift installation for a well, the qualities of which are unknown, the most difficult quantities to estimate are :—

(*a*). The economical capacity of the well.
(*b*). The drop in water level when pumping.

Both the above particulars can only be ascertained with certainty

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by test, but when there are other wells of the same nature in the locality a fairly near estimation can be made.

If the drop in water level is plotted together with the delivery of water, it will usually be found that the resulting curve is a straight line up to a certain point, which denotes the economical capacity of the well, and after this point the curve is irregular. It will usually be advisable to work the well at its economical capacity, but cases may occur of course in which it is desired to obtain the maximum quantity of water possible from the well.

The drop in water level should be determined for the delivery at which it is intended to pump the well before the final arrangement of piping is made, since this figure affects the submergence ratio. In some cases the drop of water level is so great as to render it impracticable to work in a single lift.

If conditions permit a " Compound Lift " may be employed.

A two-stage lift is shown diagrammatically in *Fig.* 2.

(V.). THE EFFICIENCY OF THE AIRLIFT.

Some of the effects resulting from variations in the various working constants of an airlift system are illustrated by the curves shown in *Fig.* 5.

The curves shown on this figure are derived from the means of a number of experiments carried out by Lieut. A. R. Evans, R.E.

The particulars of the plant, etc., were as follows :—

Well.—This was a 6-in. diameter borehole about 300 ft. deep in the chalk.

Working Lift.—About 60 ft., and did not appreciably vary throughout the tests.

Rising Main.—4-in. diameter with 10-ft. horizontal run after leaving well head.

Air Pipe.—Was central within rising main.

Three different sizes of air pipe were experimented with, viz. :— 2 in., 1½ in. and 1 in.

Air-Pipe Footpiece.—The air pipe had an open end in each case and no arrangement was adopted for splitting the air into fine streams.

Plant.—8-in. × 8-in. horizontal Ingersoll Rand air compressor driven by a de Dion 4-cylinder petrol engine, close to well head.

Investigation of the curves brings out the following points :—

(A). *For a given submergence ratio the efficiency decreased as the size of the air pipe was increased.**

The net effects of increasing the size of the air pipe (a 4-in. rising

* The efficiency referred to here is the efficiency attained so far as the losses in the rising main are concerned.

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main was used throughout), on the principles formulated in Section III., may be summarized as follows :—

(i.). The cross sectional area was decreased, thus increasing velocity and decreasing slippage losses. The relative areas, and the relative velocities of mixture per second for equal volumes with a 1-in. and 2-in. air pipe were as 1.36 to 1.00.

The above consideration would tend to increase the efficiency.

(ii.). A larger air pipe involved a reduced mean hydraulic depth, thus increasing frictional losses. The relative mean hydraulic depths using a 1-in. and 2-in. air pipe were as 1.63 to 1.00.

(iii.). A larger air pipe involved, since it was open ended, air bubbles of larger initial volume. This meant increased slippage losses, turbulence, and surgence. This was borne out by the fact that with the 2-in. air pipe the discharge was very irregular and consisted of alternate gushes of water and large gushes of air. If it be taken that the volume of the bubbles on admission varied with the area of the air pipe and the slippage with the square root of the volume of the bubbles, the slippage was about twice as much with the 2-in. air-pipe arrangement as with the 1-in.

The last two factors evidently outweighed the first, and there is no doubt that the greatest loss was due to the larger initial volume of the air bubbles. This emphasizes the great importance of dividing the air up into as fine streams as possible.

(B). *For a given submergence ratio the efficiency decreased as the volume of air per minute was increased.*

It will be well to consider first of all the following expression, which is based on the assumption that the work done on the air during isothermal compression from atmospheric pressure$=p_a$ to $p_1=$ absolute pressure at base of rising main, is available for raising water together with overcoming resistances due to the various sources of loss.

The efficiency

$$E=\frac{62.4\times V_w\times h_d}{p_a V_a \log_e \frac{p_1}{p_a}}$$

Where V_w=volume of water raised in cubic ft. per second.

V_a=volume of air used in cubic ft. per second at atmospheric pressure p_a.

p_1=absolute pressure at point of entry of air.

h_d=working lift in ft.

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Keeping all other factors constant the efficiency will decrease as V_a is increased.

It is evident that for maximum efficiency the least possible volume of air for unit volume of water raised should be employed.

This figure is governed by the impossibility of getting the lift to work below a certain proportion of air to water.

For the 1-in. air-pipe arrangement, which presented the best general efficiencies, the lowest volume of air at which the lift would work satisfactorily was about 40 ft.³/min.

The following table shows a comparison between the figures obtained in the "Evans" experiments and those got from the formula given in Section (IV.) (*d*):—

Lift in feet.	Submergence in feet.	Submergence Ratio.	Number of cubic feet free air per minute per gallon of water for maximum efficiency.	
			"Evans" Experiments.	From Formula on p. 168.
(1).	(2).	(3).	(4).	(5).
60	60	1.00	0.615	0.555
60	90	1.50	0.461	0.437
60	120	2.00	0.421	0.374

The curve plotted from the formula

$$V_a = \frac{h}{C \log \frac{H+34}{34}},$$

with air consumption and water delivery as co-ordinates, other factors being constant, should be a straight line.

The falling away of the curves in *Fig.* 5 from the corresponding straight line forms derived from the above formula, may be ascribed to increased slippage, etc., losses consequent on the use of an open-ended air pipe. Such losses will naturally increase with the amount of air in the rising main.

The falling away from the corresponding straight line becomes less as the size of the air pipe is diminished.

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(C.). *Velocities of Mixture in Rising Main.*—The velocities for the 1-in. air-pipe arrangement were as follows :—

Submergence Ratio. Lift—60 ft.	At 40 ft.^{3} free air per minute.		At 100 ft.^{3} free air per minute.	
	Velocity at top of Rising Main, in feet per sec.	Velocity at bottom of Rising Main, in feet per sec.	Velocity at top of Rising Main, in feet per sec.	Velocity at bottom of Rising Main, in feet per sec.
2.00	11.8	5.1	26.3	9.7
1.50	11.5	5 3	25.7	10.2
1.00	11.0	5.5	25.0	11.4

The velocities at 40 ft.^{3}/min. were on the low side and an increased efficiency would probably have been obtained had a smaller rising main been employed.

(D). *Variation of Efficiency with Lift.*—Owing to the fact that the water level was practically constant for all deliveries, no experiments could be made in this direction.

It is found that in general the efficiency decreases as the lift is increased.

It may be stated that modern airlift systems if properly designed, and if the well is worked at its economical capacity, should show efficiencies varying from about 50 per cent. for a 50-ft. lift to about 25 per cent. for a lift of 600 ft. For deliveries up to about 3,000 gallons an hour these figures compare favourably with the efficiencies obtainable with ordinary deep well pumps, while for higher deliveries the lower maintenance charges associated with an airlift system may often counterbalance the difference in operating efficiency.

(VI.). The Compressor and Air Mains.

It is not intended here to enter into a detailed description of the many types of compressors on the market.

Information on this subject can be found in several standard works. Compressors may be one or multi-stage, and it is generally considered economical to adopt single stage compression up to about 80 lbs./sq. in. and multi-stage after that point.

(A). *Air Compressor Installation and Operation.*—The following is a *précis* of an article on the subject by E. M. Ivens (*Power*, December 30th, 1913).

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"Instances of unsatisfactory operation of air compressor plant and disastrous explosions in receivers and air lines usually result from improper installation or negligence on the part of the attendant.

Location.—A clean and cool place should be selected with room to walk round and inspect the plant.

Foundation.—Should be designed with a view to absorbing the shocks to which a compressor is subject.

Receiver.—The functions of a receiver are :—

(1). To act as a cushion.
(2). To serve as a storage of power.
(3). To cool the air and precipitate any oil or moisture carried in entrainment.
(4). To reduce friction losses by cooling the air before it reaches the pipe line.

The receiver should be located near the compressor and in a cool spot.

The receiver should be provided with pressure gauge, safety valve, and blow-off cock.

Air-Inlet Piping.—The piping or conduit should have double the cross sectional area of the compressor inlet opening, and be arranged so as to draw air as cool as possible, and free from dust or grit. The inlet piping should have as few bends as possible.

Discharge Piping.—The pipe connecting compressor and receiver should be at least of the diameter of the discharge opening of the cylinder, and should contain as few bends as possible.

No stop valve should be placed between compressor and receiver.

Lubrication.—The same attention should be paid to the lubrication of the wearing parts as in the case of any other machine.

The lubrication of the air cylinder requires a special oil, with an ignition point depending on the degree of compression attained.

A compressor working at 70 lbs./sq. in. will discharge air at a temperature of about 350° F. The ignition point of common lubricating oil is about 295° F. and of common cylinder oil about 400° F.

The necessity for an oil of high ignition point is thus apparent.

A scored piston or cylinder wall may allow air at discharge temperature to escape back to the suction side of the piston. On the compression stroke the temperature may be raised to an abnormal and dangerous degree.

All this shows the necessity of using a suitable compressor oil and of supplying air as clean and cool as possible to the compressor.

A fusible alarm plug can be obtained for insertion in any pipe line.

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The amount of oil required for the cylinder may be gauged as follows :—

Cylinders	6 to 10-in.	stroke—	1 drop in	1 minute.
,,	12 to 16-in.	,, —3	,,	2 minutes.
,,	18 to 24-in.	,, —2	,,	1 minute.
Larger cylinders		—3 to 5	in 1	,,

Circulating Water.—The object of circulating water is to facilitate lubrication of the air cylinder.

Care should be taken when installing the compressor that the circulation is satisfactory.

It is of advantage if the water outlet is in plain view of the operator. The circulating water should be clean and its pressure should not exceed 50 to 60 lbs./sq. in.

Water jackets should be drained after shutting down, if there is danger of frost.

Inspection and Cleaning.—The compressor should be thoroughly inspected at stated intervals.

The points requiring special attention are the air valves, ports and passages. These should be slightly oily, and free from carbonaceous deposits.

The inside of the air cylinder may be cleaned effectively by filling the lubricator with a strong solution of soap and water, and feeding liberally throughout a day's run. At the end of the run, the lubricator should be filled with oil and the compressor operated for a while.

Paraffin should never be used for cleaning the cylinder, on account of its low flash point.

The following instructions might well be posted in every compressor room :—

Every Morning.

(1). Drain the receiver.
(2). Note the height of lubricating oil in the crank case (or in oil cups) and replenish if necessary.
(3). Adjust lubricator for proper amount of oil feed.
(4). Start circulating water.

Every Week.

(5). Remove crank-case oil and filter.
(6). Remove and examine suction and discharge valves. If worn or cut, they should be ground to a tight fit.
(7). Test safety-valve by raising air pressure to point of blow off.
(8). Take up lost motion in pins and bearings.

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Every Month.

(9). Renew crank-case oil and thoroughly cleanse the inside of crank case.

(10). Thoroughly inspect all parts, including air and water passages."

(B). *Air Friction and Air Mains.*—Most of the published tables giving air friction figures are incorrect, generally because the air is assumed to travel with uniform velocity through a pipe of uniform cross sectional area.

The following table gives figures for moderate air deliveries which may be taken as tolerably accurate ("Pumping by Compressed Air."—*Ivens*).

Equivalent volume in cubic feet of free air per minute passing through pipe.	Size of pipe in inches.							
	1	1¼	1½	2	2½	3	3½	4
	$P^2_1 - P^2_2$ = difference in squares of initial and final absolute pressure, per 100 ft. of pipe.							
50	150	49.2	20	4.8	—	—	—	—
75	335	98.5	46.2	10.5	—	—	—	—
100	600	197	79	18.8	6.15	—	—	—
150	1350	443	178	42.2	13.8	5.5	—	—
200	2400	788	316	75.0	24.6	9.9	2.0	2.4
250	3750	1230	494	117	38.5	15.4	7.1	3.6
300	5400	1770	711	168	55.4	22.2	10.3	5.3
400	9600	3150	1263	300	98.3	39.5	18.2	9.4
500	15000	4920	1978	470	154	62	28.5	14.6

As an example, suppose the following to be the data given :—

Volume of free air—100 ft.³/min.
Length of air main—2 miles.
Compressor working pressure—100 lbs./sq. in.
Terminal working pressure—90 lbs./sq. in.

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It is required to find the size of the air main necessary.

$$P_1^2 - P_2^2 = (114.7)^2 - (104.7)^2$$
$$= 2196 \text{ for } (2 \times 5280) \text{ ft.}$$

Then $$P_1^2 - P_2^2 \text{ per } 100 \text{ f.r.} = \frac{2196 \times 100}{2 \times 5280} = 20.8.$$

From the table it will be seen that a 2-in. pipe will be a suitable size.

Transmission of power by compressed air offers many advantages in certain cases, especially in borehole work, since a range of boreholes can be worked from a centrally situated compressor station. In this system, either of two methods of operation may be adopted. In the first method each well is worked separately for a certain period each day, and the compressor furnishes only sufficient air to work one well. The wells may be connected to the compressor by independent air mains or may be teed off a common main with a valve at each well.

In the second method all the wells are worked simultaneously, and the compressor furnishes enough air for the purpose. In this case the delivery to each well is usually teed off a common main of suitable size to carry the requisite volume of air for the wells supplied.

The former method possesses the advantage that it is easily operated and does not require adjustment of pressure at each well to take care of variations of water level (and consequently variations of submergence and working pressure).

Where, however, several wells are worked in order to obtain the united delivery of water from them all, the second method must be employed. It is rarely possible to adjust the submergences so as to obtain an equal working pressure at each well, so some form of pressure regulating valve on each air delivery must be provided.

It is desirable to insert a second cock so that the well may be shut off without disturbing the setting of the regulating valve.

As regards laying air mains, it is most necessary that good joints should be made. Ordinary screw joint water pipe is quite suitable for moderate pressures.

The sealing compound should be applied to the male end of the joint, otherwise it is liable to be squeezed inside the pipe.

The pipe used should be clean and care taken that dirt is not introduced during laying. In pronounced dips in the line a blow-out cock should be inserted to release any water that may collect, but this is only necessary in long lines.

A similar cock should be provided at the end of the line.

When the line is complete, it should be filled with air rather above

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working pressure and examined for leaks—these are a fruitful source of loss of power. It is a good plan then to hammer the pipe well all along and suddenly release the pressure.

This will loosen and remove any scale remaining in the pipe.

Surface lines should have some provision for expansion.

The best plan is to lay in a curve on supports that will not resist a slight movement. Expansion joints generally leak.

NOTE.

The Airlift pump has so firmly established its reputation in the Field that it is thought that these few notes on the theory and practice of Airlift Installation may be of interest. It is not pretended that the information given is the result of original research, it is rather an attempt to present what may be called the "Algebraic mean" of information already published in various forms and which has been borne out by personal practical experience.

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AIRLIFT PUMPS

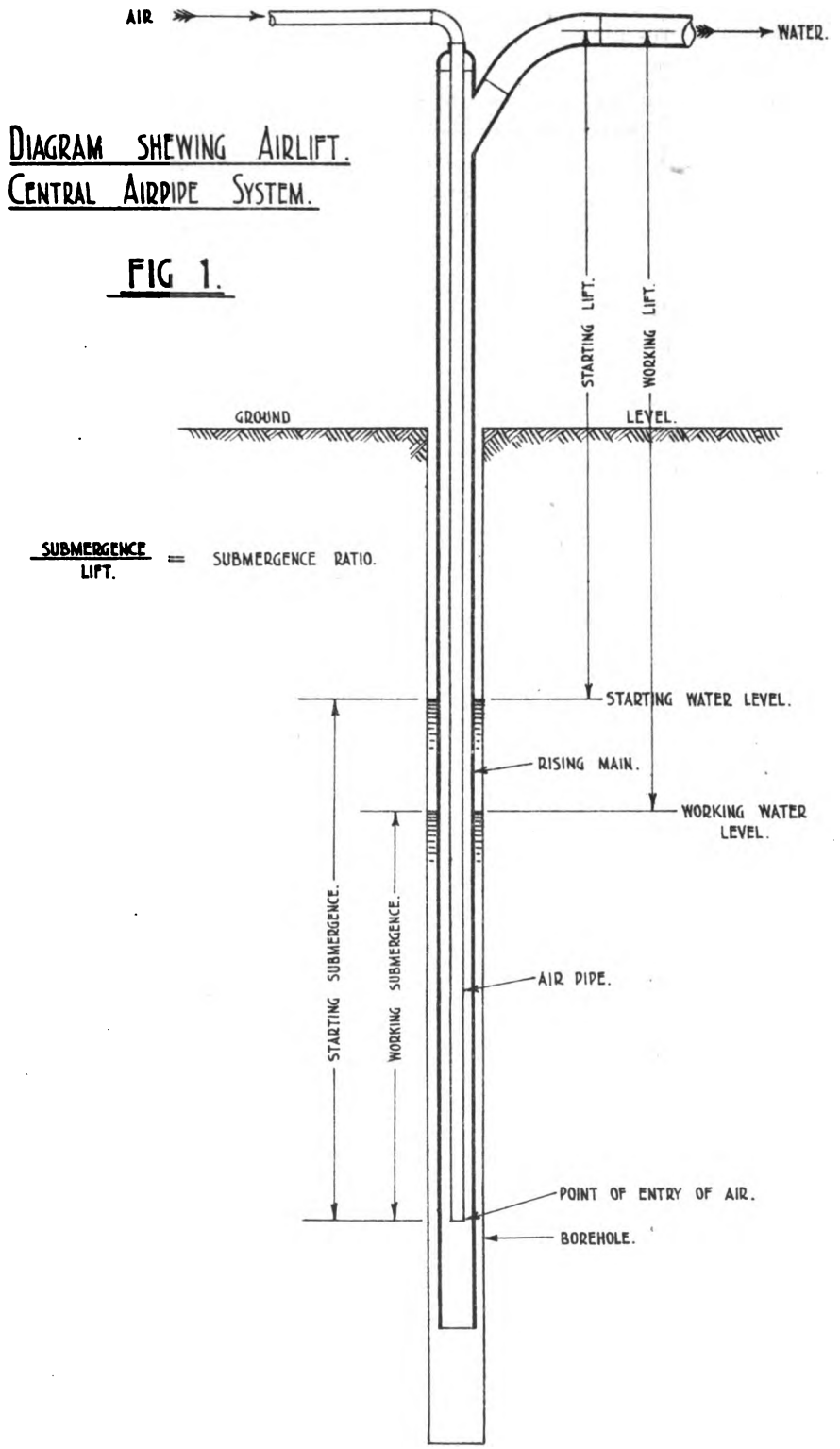

DIAGRAM SHEWING AIRLIFT.
CENTRAL AIRPIPE SYSTEM.

FIG 1.

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FIG. 2. — COMPOUND AIRLIFT. —

COCK "A" IS KEPT SHUT AND COCK "B" OPEN UNTIL WATER LEVEL IS SUFFICIENTLY LOWERED. "A" IS THEN OPENED AND "B" SHUT, AND THE AIRLIFT OPERATED BY MEANS OF THE INNER AIRPIPE.

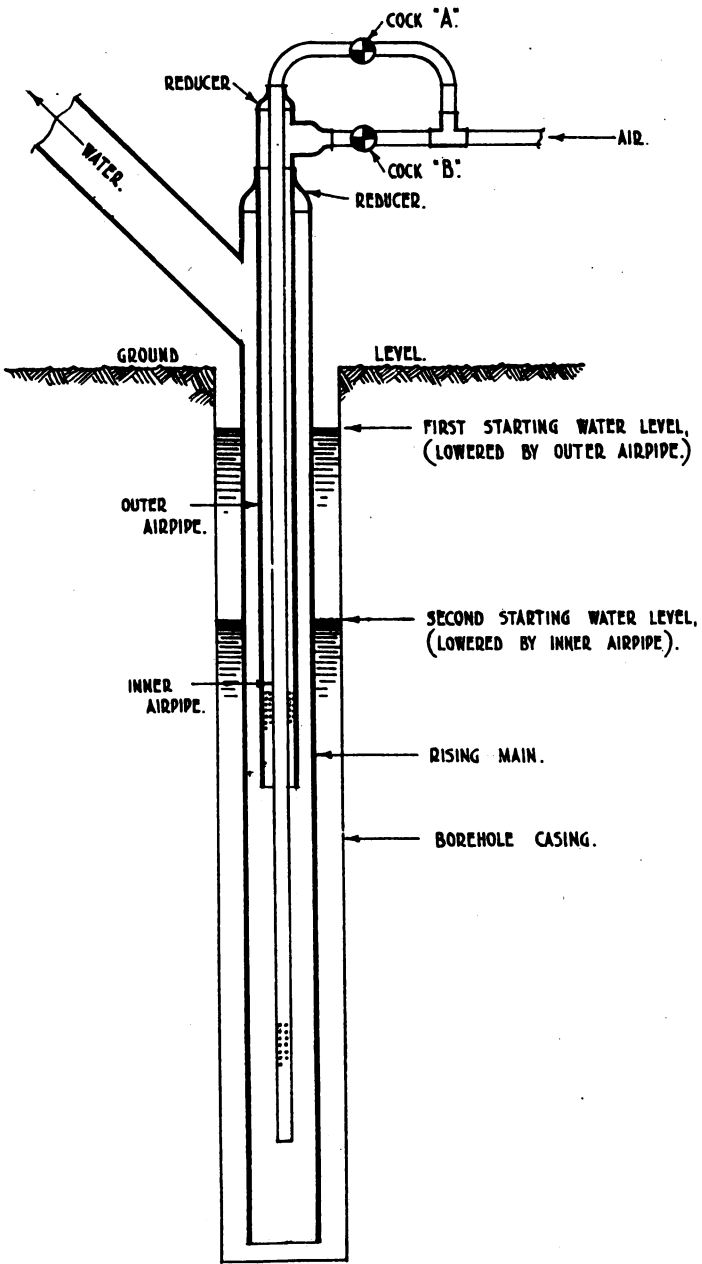

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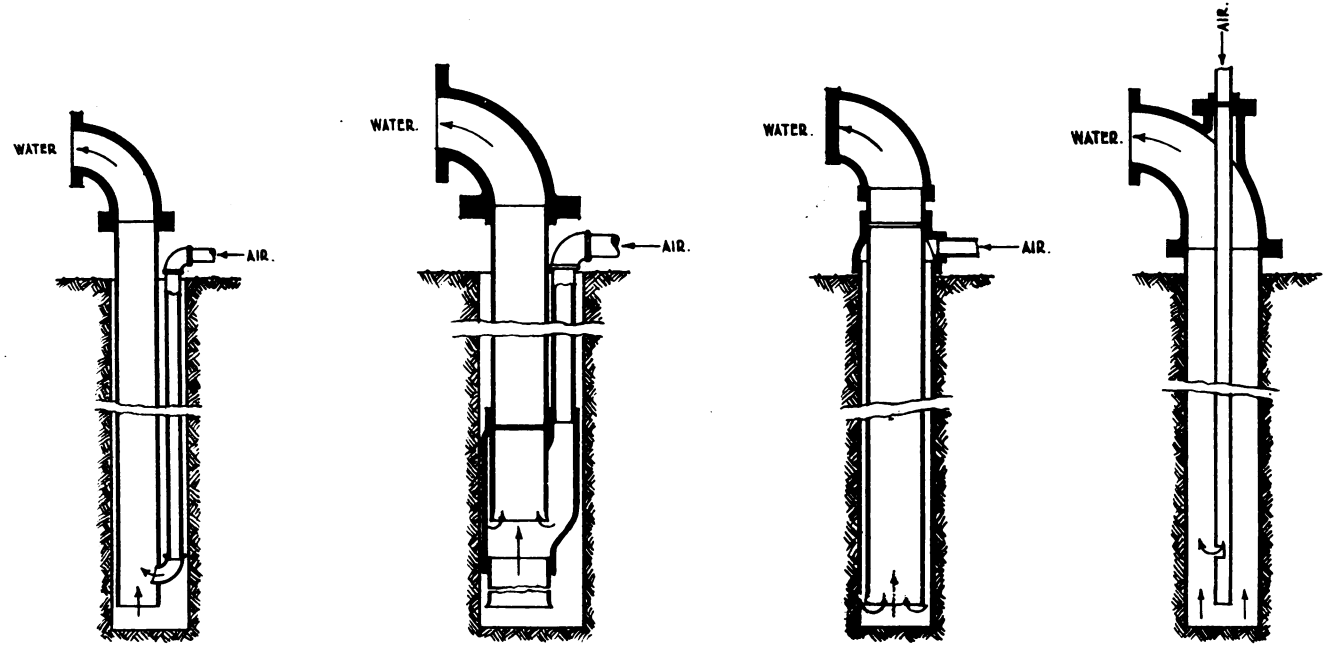
FIG. 3.

— METHODS OF PIPING WELLS. —

FROM DIAGRAMS CONTAINED IN INGERSOLL-RAND COY'S CATALOGUE Nº 76.



AIRLIFT PUMPS

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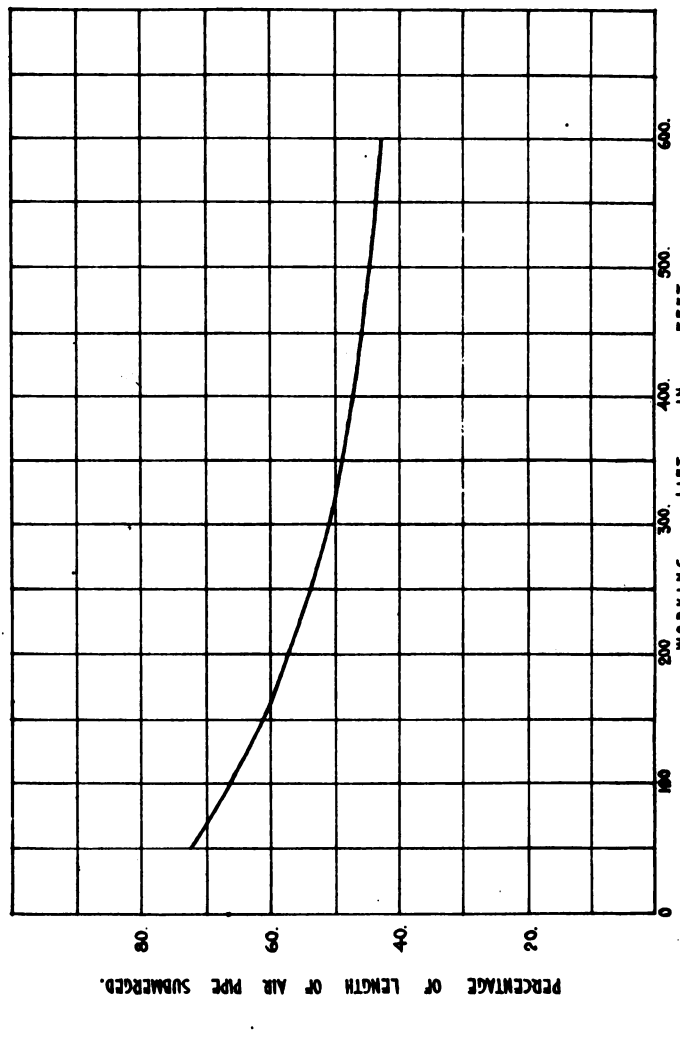
FIG. 4.

CURVE GIVING MOST EFFICIENT SUBMERGENCE FOR VARIOUS LIFTS.

(FROM "IVENS' PUMPING BY COMPRESSED AIR").



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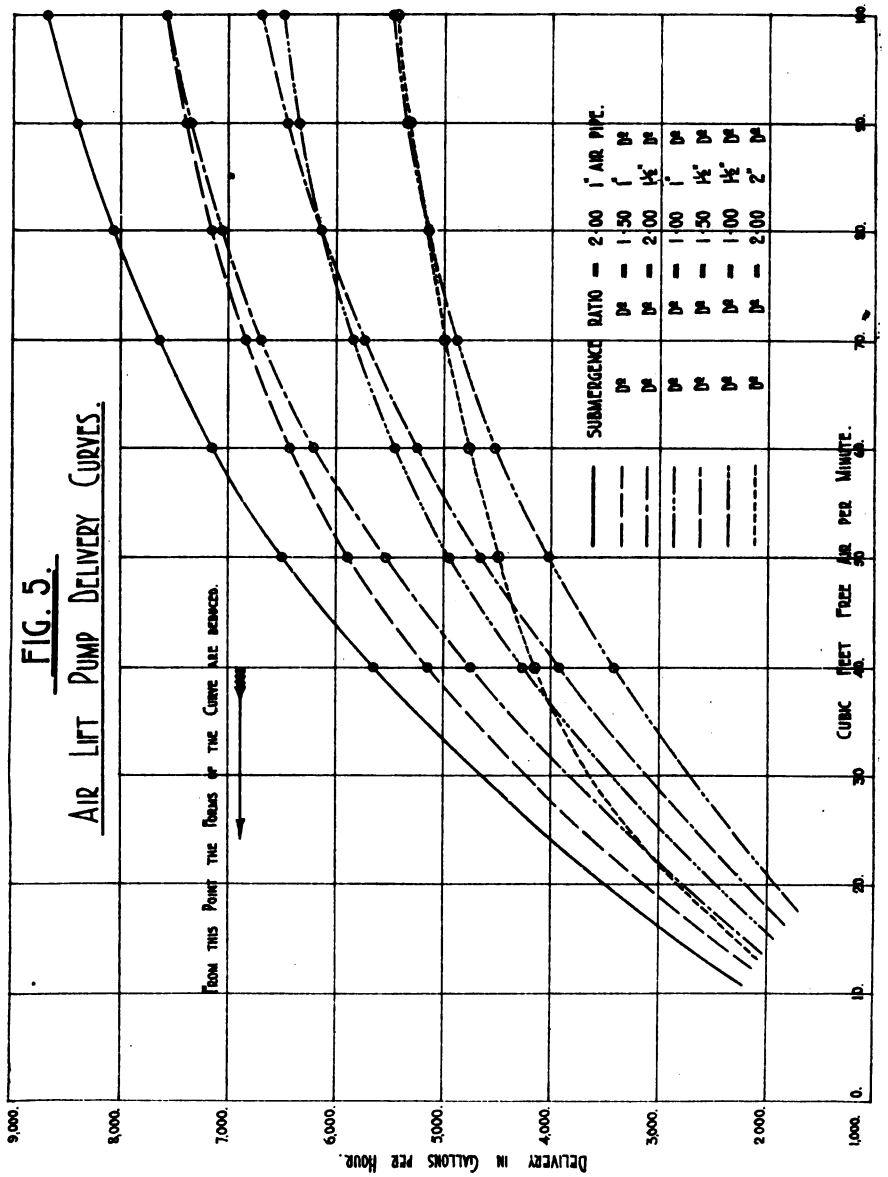

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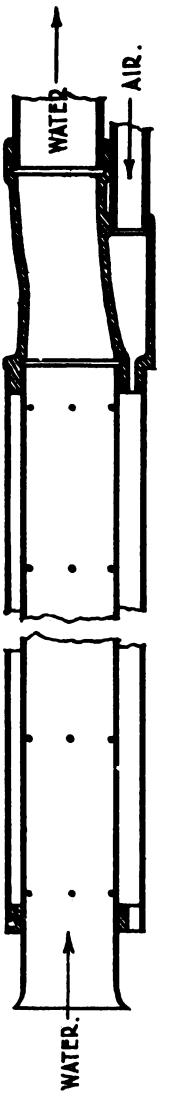

FIG. 6.

THE "HARRIS" AIRLIFT PUMP.

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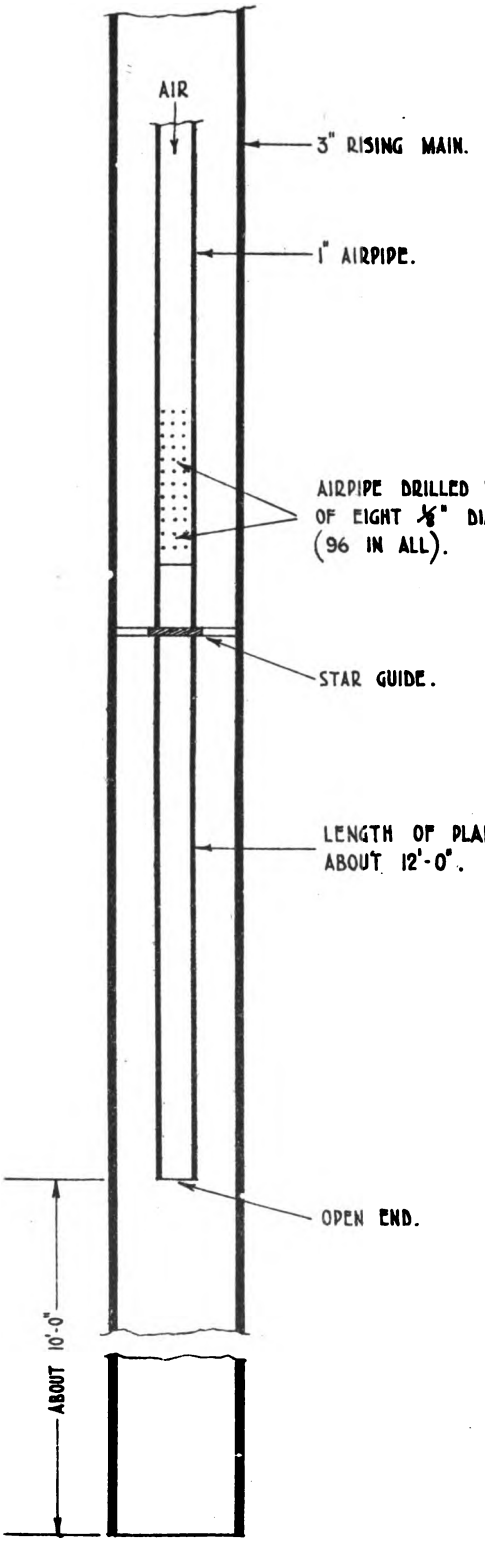

FOOTPIECE FOR AIRPIPE.
CENTRAL AIRPIPE SYSTEM.

FIG 7.

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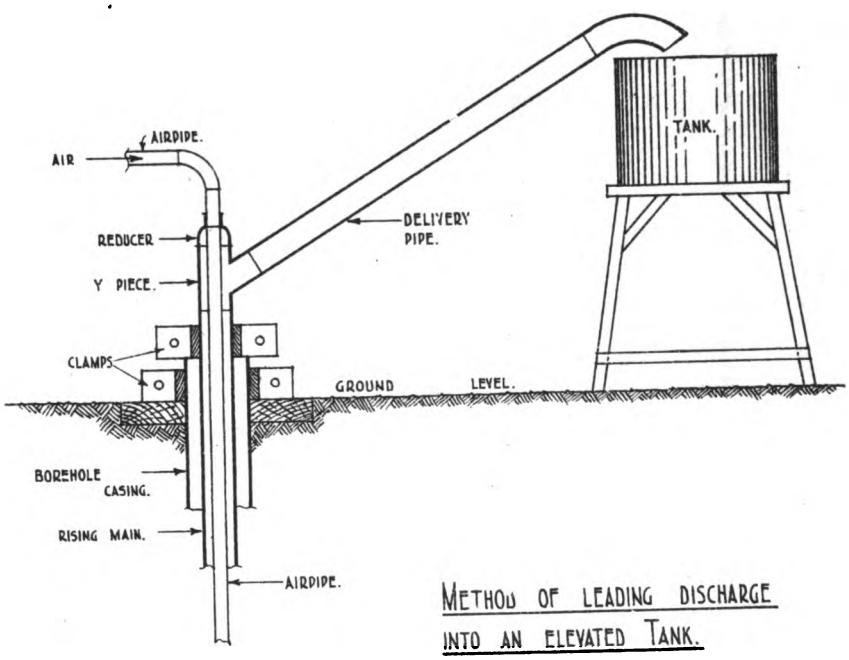

METHOD OF LEADING DISCHARGE INTO AN ELEVATED TANK.

FIG 8.

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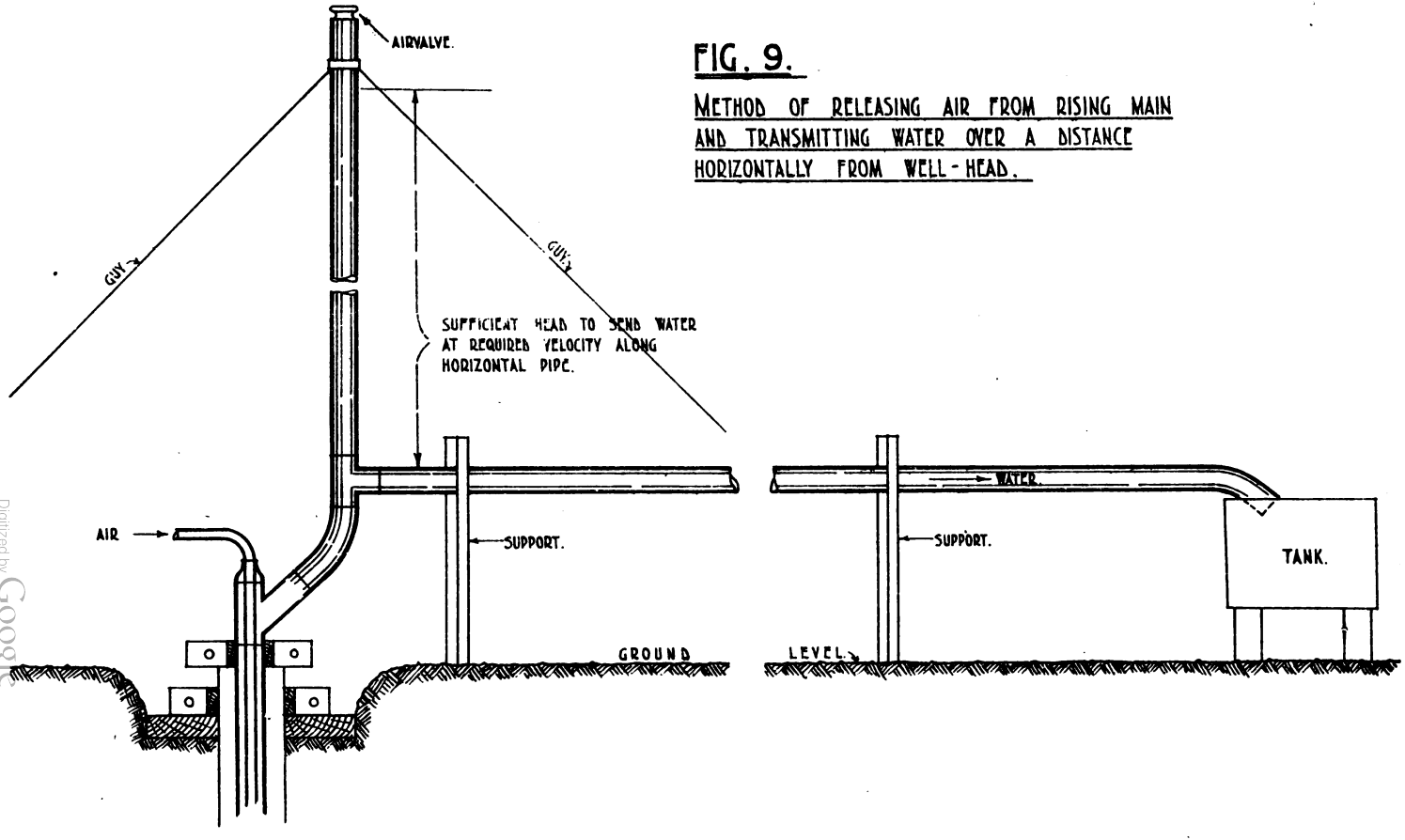

FIG. 9.

METHOD OF RELEASING AIR FROM RISING MAIN AND TRANSMITTING WATER OVER A DISTANCE HORIZONTALLY FROM WELL-HEAD.

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FIG. 10.

METHOD OF LEADING DISCHARGE AWAY FROM WELL HEAD.

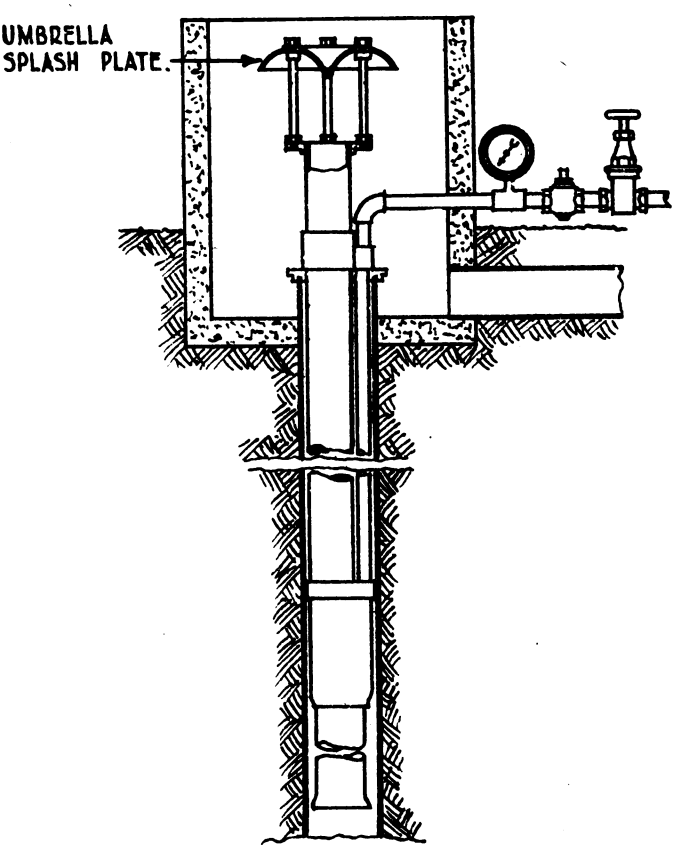

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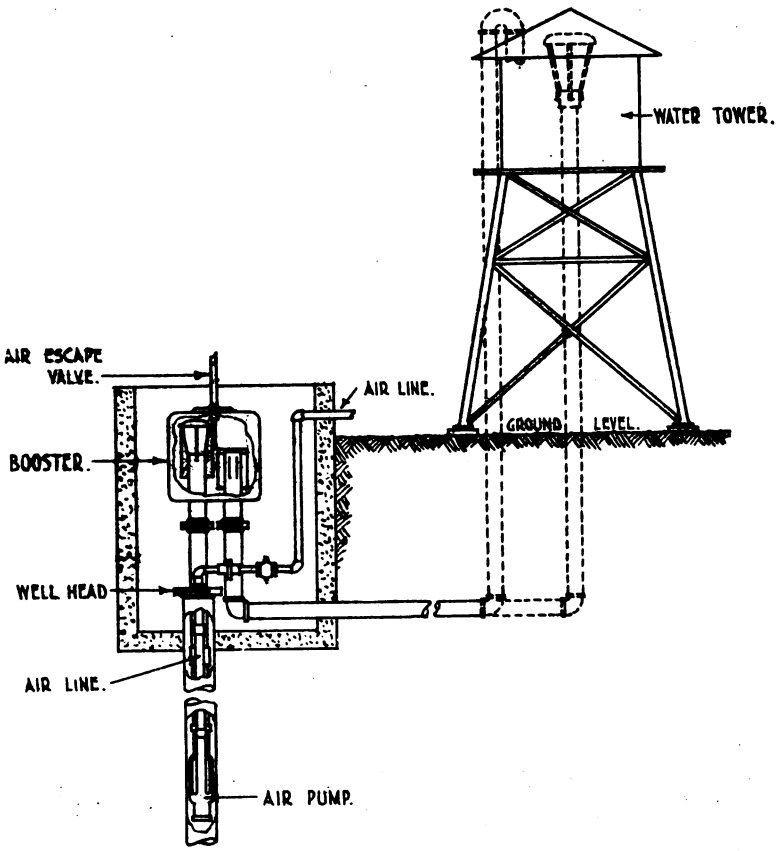
FIG. 11.

THE "HARRIS" BOOSTER PUMP.



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AIRLIFT PUMPS

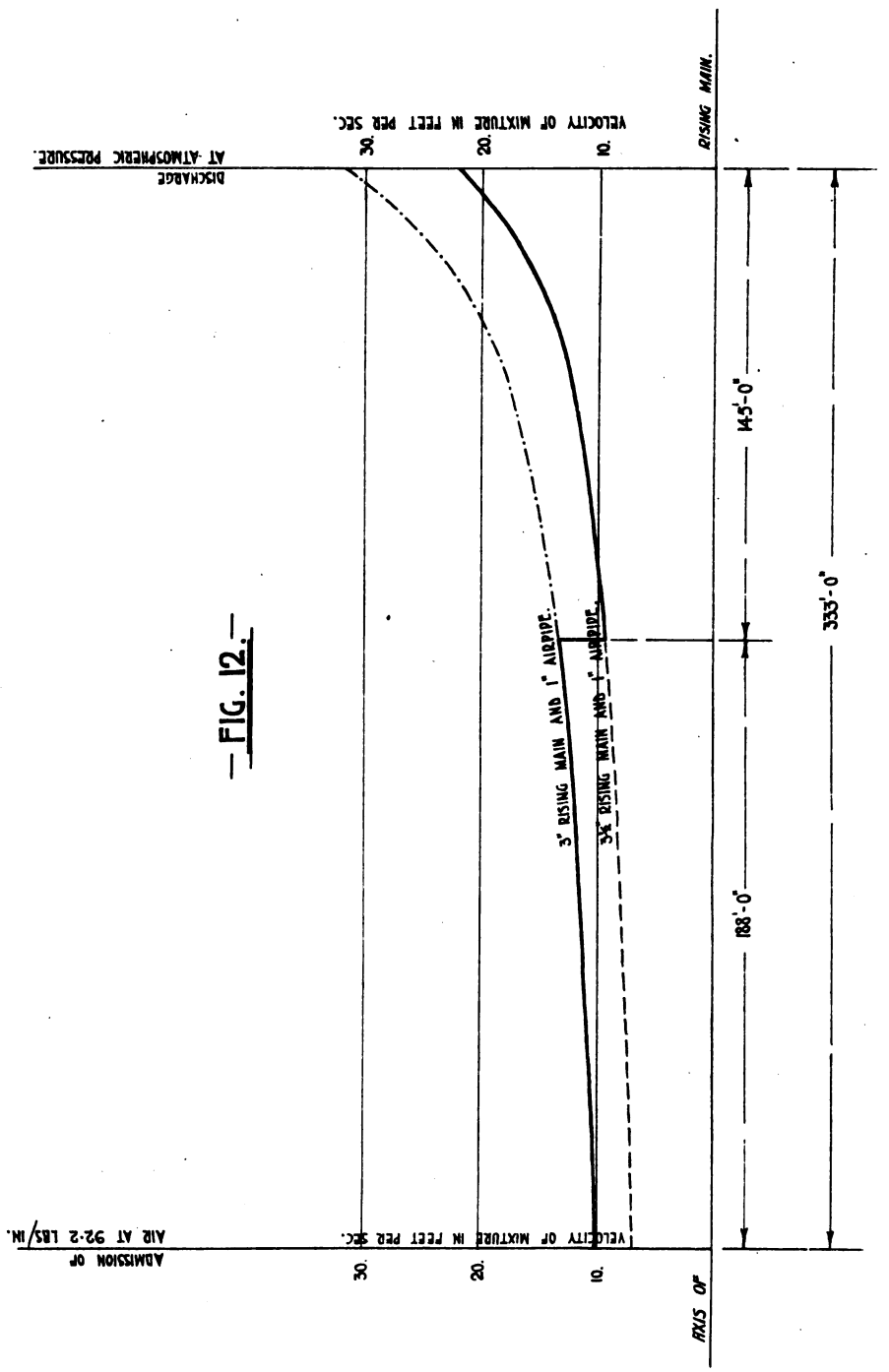

FIG. 12.

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REVIEW.

TELEGRAPHY, AERONAUTICS, AND WAR.

By CHARLES BRIGHT, F.R.S.E.—(Constable & Co. 16s.).

THE author of this volume is a well-known authority on telegraph matters; he has read several papers on the administration of Telegraphs and allied subjects before important bodies and has contributed many articles on similar questions to the leading periodicals. Mr. Bright, it may be remembered, served as a Member of the Committee of Enquiry appointed in 1916 to deal with questions affecting the Administration and Command of the Royal Flying Corps; whilst so engaged he prepared a series of "Additional Recommendations," and some supplementary memoranda on aeroplanes, aero-engines, etc., which are incorporated in the Final Report of the Committee in question. During the War, Mr. Bright has prepared a number of memoranda on cable and "wireless" communications, the censorship and other telegraph matters for the information of the War Office, the Foreign Office, the Colonial Office, etc.

The volume under notice contains reprints of a number of Mr. Bright's more recent papers and articles and also of the memoranda referred to; they are preceded by an "Introduction," separate sections whereof are devoted to War, Aeronautics, and Telegraphy. Addresses, entitled "A Nation's Awakening" and "Nothing as Usual," delivered by Mr. Bright in various parts of the country on behalf of the Victoria League are included in the volume, which is completed by the insertion of a useful table giving approximate cable distances from London to various important centres and the ordinary cable rate thereto, and also of a Telegraph Map of the World.

The papers and articles reprinted in this volume, though mainly devoted to the commercial aspect of our overseas communications, deal also with the strategic aspects of a proposed Inter-Imperial Cable network. Many problems connected with "wireless" telegraphy are discussed by Mr. Bright, who deals, *inter alia*, with the advantages and disadvantages of the submarine cable in comparison with those of "wireless," as a means for providing safe and sure communication with the Overseas Dominions and the outlying portions of the British Empire. The vexed question of the provision of "fixed" defences for localities where mportant British cables are landed is also touched upon. Several of the problems dealt with by Mr. Bright are likely to come up for consideration, with a view to their settlement, in the immediate future. The information contained in the volume under notice will prove of value to all who either take an interest in or are obliged to concern themselves with those questions which affect our overseas communications, whether in war or in peace.

W. A. J. O'MEARA.

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NOTICE OF MAGAZINE.

REVUE MILITAIRE SUISSE.

No. 8.—August, 1918.

HEAVY FIELD ARTILLERY BEFORE THE WAR.

The original article on the above subject is contributed by Lieut.-Colonel E. Mayer (Emile Manceau), who discusses the question therein whether heavy artillery has, in the present War, justified its existence. He tells us that very recently a distinguished French artillery officer remonstrated against the infatuation of the public for the heavy type of field piece. The adoption by Germany of short-range trench guns had provided the officer in question with a pretext for condemning long-range heavy guns, for declaring them to be useless, and even an encumbrance. This condemnation was based on the argument that long-range artillery fire, the effects of which cannot be observed, must be ineffective ; the condemnation is summed up in the following terms :— " Long-range artillery fire, the dispersion of which is excessive, should not be resorted to. The example set by the Germans in reducing the range of their 8-in. gun from 10,000 to 2,500 metres should be followed. It is even necessary to go one better. The gun should be placed within a few hundred metres of its target, and the accuracy of its fire increased by this means tenfold. It is further necessary to increase, in a tenfold degree, the rapidity of bringing guns into position and in moving them from place to place ; the rapidity of their fire, the explosive force of their ammunition, and its quantity, should be multiplied to as great an extent as possible. In a word, what is wanted is a light short-range gun, with a curved trajectory, capable of affording rapid and accurate fire ; its projectile should be a mere container for explosive material and should, therefore, consist of a thin sheet of steel."

The object to be aimed at, it is stated, should be to cover with a rain of explosive matter, propelled from trench guns, the ground over which the waves of attack must pass rather than to employ an armament constructed for other purposes ; one therefore which is not particularly suitable, to attain the end in question.

Colonel Mayer points out that there are directions in which long-range artillery can be usefully employed ; it is wrong, therefore, to suppose, as some do, that because a particular instrument cannot be used for every purpose, it can have no value for any purpose whatever.

It is true that heavy artillery has not come up to all expectations ; on the other hand, it has to be remembered that it could have been usefully employed for many purposes, other than the tasks assigned to it, had a demand been made for further support from this arm. Long-

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range artillery has "proved in," and, even if new models of trench guns are being designed and manufactured, all the belligerents will still continue to build long-range heavy artillery and are certainly not going to do without its powerful aid.

Examining the origin of heavy field artillery, Colonel Mayer points out that the problem of the introduction of this arm was not approached *a priori* or deliberately; like so many things else heavy field artillery owes its existence to chance. Armies had been provided with light siege trains before the War; there being no immediate use for them after they had accomplished the tasks for which they were originally intended, it was soon recognized that the pieces composing these trains could be utilized for a purpose which was beyond the capabilities of ordinary field artillery. This idea was seized upon and soon put into practice.

Such a use of heavy artillery had been discussed in a prophetic work by Capt. (now Major) Gabriel Glück, entitled *The French Artillery in Contest with Germany Heavy Artillery* (published by Chapelot in 1914). Colonel Mayer gives us an outline of the contents of Capt. Glück's work in the original article.

The French having, after the War of 1870, fortified their Eastern frontier in order to bar the routes leading into the interior of France from the Rhine, the Germans, imbued with the doctrines of Clausewitz, felt that, in the event of their attempting another invasion of the territories of their Western neighbour, their best plan would be to strike quickly at the heart of France and to attempt to reach it as soon as possible, without waiting to reduce the entrenched camps intended to impede their progress to their main objective. These camps they proposed merely to invest. The Germans had, however, to reckon in addition with the *forts d'arrêt* which the French Engineers had built in such positions that they could not be similarly turned. The Great General Staff hoped that by means of the *attaque brusquée*, delivered with extreme violence, and with engines of War specially designed for the purpose, it would be possible to readily reduce the last-mentioned forts and thus quickly to open a route for Germany's invading columns. With this object in view the German Army was provided with parks of light siege guns consisting of 15-cm. (approximately 6-in.) howitzers and 21-cm. (approximately 8-in.) mortars.

Major Glück, discussing the question of the employment of these light siege guns in the work referred to above, pointed out that, after the principal task for which they had been introduced had been accomplished, a further opportunity for their employment would be found against the enemy's strong points and field entrenchments. The possibility of utilizing the parks of light siege guns as heavy field artillery was facilitated by the fact that the Great General Staff had, in 1892, provided horse-transport for the garrison artillery batteries armed with the siege guns and had, subsequently, year by year brought about an assimilation of this branch of the artillery to the other field troops. By degrees, the *rôle* originally assigned to the light siege guns was enlarged and steps were consequently taken to enable them to undertake wider duties on the field of battle. Major Glück refers to the subject in the following terms:—"The organization of the units, the increase in their

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establishments, the improvements in their equipment, all tend towards this object. The garrison artillery takes part in the combined manœuvres with the other arms; the brilliant part played by the garrison artillery of the Guard at the Imperial Manœuvres of 1900, caused the Kaiser, at the Conference, to award to the 15-cm. howitzer, the title of *heavy field howitzer*, a title which it still retains. To-day (1914) the heavy batteries of the field army have become an important factor with which the High Command must reckon from the moment a campaign begins."

After the experiments carried out at Thorn, shortly before the War, were completed, General von Dulitz, Inspector-General of Garrison Artillery, claimed the premier *rôle* for the arm which he officially represented; he urged that heavy batteries should be organized and that they should be at once brought into action in the initial stages of a battle owing to their greater range. Naturally, General von Schubert, the Inspector-General of Field Artillery, was unable to accept such a claim; his views on the subject were expressed in the following terms:—

"An arm as powerful as the garrison artillery should be reserved for the destruction of defined objects. It would be wasteful to bring it into action before the situation has been cleared up. Besides, one cannot be blind to the fact that its presence at the head of the columns would be an impediment to their progress and the coming into action of the heavies at the beginning of an engagement could only delay the entrance into the fray of the field artillery."

The divergent views of the two Inspectors-General are mirrored in the German regulations relating to the employment of the new artillery arm. The first of these regulations was at first kept secret and only became public property in June, 1906; the text therefore was revised and modified in November, 1908. The participation of battalions of 15-cm. howitzers in a field campaign was definitely provided for in this revised text and units of heavy howitzers have since formed an integral part of the German Army Corps. The regulations relating to the use of this arm issued in June, 1911, and in March, 1912, were only amplifications of those promulgated earlier. It is not the text of the regulations but the comments thereon by German officers that gave a true indication of the intentions of the High Command concerning the part this arm would play in the theatre of operations.

In the preface to the latest regulations, it is stated that reliance is placed on this arm "to open the road to victory for the infantry," and, in paragraph 358, it is laid down that the heavy artillery "shall act in co-operation with field artillery" in support of the infantry; the regulations are so framed that they meet, to some extent, the conflicting claims of the two Inspectors-General.

Paragraph 365 of the regulations of March, 1908, had decreed that the heavy batteries were to march in rear of the regimental trains of the field artillery. This decision gave rise, at the time, to lively polemics; it was held to be illogical. The value of the heavy pieces was soon recognized and a modification of the regulations immediately followed.

Paragraph 417 of the new regulations ran as follows:—"If an Army

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Corps marches on a single road, the heavy artillery should, as a rule, be attached to the leading division; its place in the column should, under ordinary circumstances, be immediately in rear of the infantry. If the possibility of bringing it into action early in an engagement is foreseen, it should occupy a more forward position in the column; under certain circumstances it may even be necessary for it to march in front of the main body of the field artillery. It will be necessary to consider, in such a case, whether the forward position to be assigned to the heavy artillery is likely to prejudicially delay the field artillery, and, above all, the infantry in coming into action."

In the battle, it was intended to employ the German heavy batteries grouped; they were to come into action by whole battalions, under the orders of the Divisional General to whom they were temporarily assigned. It was contemplated that the employment of these batteries as Corps Artillery would be exceptional.

The heavy batteries were enjoined to come into action in invisible and masked positions, so that hostile artillery would find them a difficult target; these positions were, as a rule, to be in rear of those required by the field artillery.

Such an arrangement provides two tiers of fire, but in the case of artillery is inconvenient, owing to the difficulty in observing the effects of the fire. The German regulations lay stress on the importance of having a properly organized chain of observation posts to meet the situation, and instructions are set out for the guidance of the infantry and cavalry for the purpose of preventing undue interference with these observation posts. The necessity of providing uninterrupted communication between the positions of the batteries and the advanced infantry fighting line is also insisted upon. (There are some French writers who are of opinion that it is almost impossible to provide communications of this nature with certainty and have argued from this assumption against the employment of heavy field artillery).

Summing up the position of affairs before the War, Colonel Mayer states that the Germans reckoned on employing their battalions of mortars against the French *forts d'arrêt* and strongly fortified positions; whilst the long heavy guns were intended for use against the enemy's billeting areas and for long-range fire against advancing columns, in order to bring about their premature deployment, thus to cause the enemy to advance for a greater distance across the fields instead of along the highways. It was expected that his *morale* would thereby be lowered. Heavy guns stationed on the flanks of a position would, it was further argued, deter an attack against those flanks and compel an enemy to make wide turning movements for the purpose of effecting the capture of such a position.

Paragraph 358 of the regulations of 1908 contained an instruction that the German heavy artillery should engage *all* enemy artillery, even guns in invisible or masked positions; every means, *e.g.*, aerial reconnaissances, etc., were to be adopted, for locating such masked guns as early as possible.

Major Glück states in his work that the German Army Corps, in addition to its complement of 144 field pieces (*i.e.*, 108 77-mm. guns and

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36 light howitzers), had a number of heavy pieces, manned by garrison artillerymen, viz., 15-cm. howitzers, 21-cm. and 28-cm. mortars and 10-cm. and 13-cm. guns.

The German garrison artillery, like the other branches of the German Army, had had its establishment largely increased by recent legislation. In the spring of 1914, it consisted of 25 regiments, or 50 battalions, comprising 193 batteries. At the beginning of the War the Germans had, in round numbers, 700 heavy guns ready to take the field.

Normally, each German Army Corps had attached to it a battalion, *i.e.*, 4 batteries of 15-cm. howitzers.

The remainder of the garrison artillery, attached to the field army, consisted of about 30 batteries (125 pieces) of 21-cm. mortars and of 80 to 90 batteries of 10-cm. and 13-cm. guns.

In the original article many details regarding the German heavy artillery and its ammunition are furnished by Colonel Mayer.

THE GERMAN ATTACK ON LIEGE.

The original article, which is accompanied by a sketch-map of E. Belgium, is written by Colonel Feyler, who has obtained his materials mainly from German official sources—principally from Part I. of the publication *Der grosse Krieg in Enizeldarstellungen*, prepared by the Great General Staff, entitled "Lüttich-Namur" (Mittler & Sohn, Berlin). The Great General Staff's publication has been prepared for propaganda purposes rather than from the point of view of a military historian; many of the statements contained therein are deliberately false.

Colonel Feyler points out that the German *coup de main* against Liège is one of the pieces of evidence pointing to the fact that the present War had for some time been premeditated by Germany. A short description is given in the original article of the defences of Liège; these consisted of 12 detached forts with unfortified intervals between them—five of these forts were situated on the right bank of the Meuse and the remaining seven on the left bank of this river.

The *coup de main* was directed by General von Emmich, Commanding the X. A.C.; his troops advanced to the attack on the morning of the 4th August, 1914. Two cavalry columns, under the command of General von Marwitz, formed the covering screen of the force detailed for this purpose; one of these columns, consisting of the 2nd and 4th Cavalry Divisions, advanced along the Dutch frontier, whilst the 9th Cavalry Division, constituting the second column, was directed on to the lower course of the R. Ourthe.

The above cavalry force was followed by six mixed brigades; they crossed the Belgian frontier at 9 a.m. on the date named and marched concentrically towards the Belgian fortress. Three of these brigades, the 34th, 27th and 14th advanced from Aix-la-Chapelle; one, the 11th, from Eupen; and two, the 38th and 43rd, from Malmedy. The 34th Brigade, after crossing the Meuse at Lixhé, on the 5th August, wheeled to the left and deployed against the N.W. forts of Liège. The 27th and 14th Brigades advanced against the N.E. forts; the 11th Brigade formed up on the left of the 14th Brigade; at the same time, the two

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brigades from Malmedy were directed, astride the R. Ourthe, against the S.E. forts of Liège.

The attack on Liège was delivered on the night of 5th–6th August. The bombardment of the N.W. forts by 21-c.m. mortars began at 2 p.m. on the 5th *idem*.

At daybreak of the 6th *idem*, the Germans found that their attack had failed at all points except one, where the results were, however, still indecisive. The troops of the 14th Brigade had passed through the interval between two of the E. forts and had reached the outskirts of the town, under the old citadel of *La Chartreuse*. The other brigades had been obliged to retire. The 14th Brigade had broken off the fight; it was reduced to 1,500 men and its ammunition supply was nearly exhausted. It approached the town with caution; it met with no resistance, the Belgians had abandoned the portion of Liège situated on the E. bank of the Meuse.

The 14th Brigade uncertain as to its communications was in a most uncomfortable position. However, on the morning of the 7th August, as the Belgians did not counter-attack, the decision was arrived at to enter the town; the bridges over the Meuse were, in consequence, crossed and it was then found that Liège had been completely evacuated. The 3rd Belgian Division, detailed to defend the town during the concentration of the Belgian Main Army, had been ordered to fall back on the Gette where it joined up with this main army, which had completed its mobilization and had taken up its assigned position on the river.

Meanwhile, all the detached forts at Liège were still held by their original garrisons; they commanded all the approaches to the river crossings. General von Einem was directed to reduce these forts, as a matter of urgency; the IX., VII. and X. A.C., also parts of the VIII. and IX. A.C. and some heavy guns and siege artillery were placed under his command to effect this purpose.

The intention had been to capture the N. forts first of all, and as early as possible, in order to permit the German I. Army to continue its advance westward, along the Dutch frontier. The first of these forts—viz., Barchon on E. bank of the Meuse—surrendered on the 8th August, and two others—both on W. bank of the river—were taken on the 13th and 14th *idem*.

In order to secure the river crossings completely, it was necessary to capture the W. forts, as well as those on the N. and E. of the town. The last of the Liège defences fell into German hands on the 15th and 16th August, and on the 17th *idem* the advance of the German Army on Brussels was recommenced.

The Great General Staff asserts that everything in connection with the attack on Liège worked out according to plan. According to the Berlin authorities their scheme was as follows:—

Weak brigades, at peace establishment, were detailed for the *coup de main* against Liège. Owing to the success, with which they met, it was possible immediately to bring them up to War establishment. At the same time, the German Main Army was being concentrated in the Liège region. When, thanks to the success of the *coup de main* whereby

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the forts were taken in reverse, the last of these forts fell the concentration of the Main Army was already completed; consequently, the German I. Army was able at once to take up, on the left bank of the Meuse, the line from which it was to advance westward. The general deployment, according to programme, was therefore proceeded with.

Colonel Feyler points out that if the above statement accurately represents the German scheme a period of fifteen days was occupied by the German Main Army in its concentration, within one day's march only from the Belgian frontier defences, and that its advance into the interior of Belgium began on the sixteenth day after the orders to mobilize were issued.

It is necessary to assume that the *coup de main* against Liège was an essential element in the German plan of campaign. This plan, as is well known, involved the march of seven German Armies on the N.E. and N. frontiers of France, *i.e.*, towards the front extending from the Donon region to the Lille region. The left wing of the German Army, consisting of 8 A.C., marked time, whilst the right wing, consisting of 28½ A.C., pivoting its left flank on Thionville, was swinging round, so as to form front on a line west of the Moselle. A line drawn from a point of the Meuse just below Liège to a point on the Scheldt just below Tournai measures 170 km. (approximately 105 miles) *i.e.*, a 7-days' march. It was intended by the Germans that the invasion of France along the whole line should take place simultaneously.

In the main, the German advance did actually take place as outlined above, with the exception that the German right wing extended slightly beyond the limit mentioned. The collision of the German forces with the British Army at Mons occurred at midday on the 23rd August.

In order to determine the real value of the attack against Liège and to settle the point whether it was successful or not, it is necessary to know whether the Great General Staff had reckoned with the possibility of the German Armies being heavily engaged on the 21st and 22nd days after the order to mobilize was issued, and, if so, whether it was contemplated that such engagements would take place on the Namur heights, or on the N. frontier of France (towards Lille). Colonel Feyler points out that if the Great General Staff did anticipate that a battle would take place at so late a date, the course adopted in sending an ultimatum to Belgium as early as the 2nd August and the attempted *coup de main* with *non-mobilized* forces on the 4th, 5th and 6th *idem* require a good deal of explanation. Germany's wiser course, from all points of view, would have been to complete all her arrangements and then to strike with united forces. If the Great General Staff reckoned on capturing Liège with six weak brigades and two battalions of heavy artillery, the success of such an operation could not have been made less certain by employing a similar number of formations on a War establishment. Namur was captured by von Bülow's Army in three days.

By adopting the course suggested by Colonel Feyler Germany would have gained the further advantage that her intention to advance through Belgium would not have been disclosed from the first day of

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the War, and thus France might not have taken steps to bring about, in time, a redistribution of her armies to meet the attack against her N. frontier. If a battle on the 22nd day of mobilization had been foreseen by the Berlin authorities, it is evident the *coup de main* against Liège on the third day of mobilization constituted a benevolent warning to France, affording her three weeks in which to make her preparations to meet the serious dangers threatening her. Colonel Feyler is of opinion that an act implying such kindly consideration on Germany's part towards her foe requires for its acceptance as a fact a good deal of credulity.

The maintenance of the utmost secrecy in the arrangements being made by Germany for the invasion of France was essential in order to promote the success of the German plan of campaign. However, the Belgians early became aware of the presence of five German A.C. on their frontiers and having received information that two more A.C. (the III. and IV.) were mobilizing at Malmedy and St. Vith, they concluded, not without reason, that "seven A.C., 300,000 men approximately, were being concentrated on the roads leading into Belgium, which were barred by the fortress of Liège." (*Vide* Report of Army Commander at page 11 of *L'action de l'armée belge*).

Liège and Namur lie about 19 miles apart. Brussels is only some 47 miles distant from Liège, say three days' march; as soon as the forts of Liège fell it became possible for the Germans to advance to and take up a position on the line Brussels-Namur in four days, as actually occurred. Von Klück's Army, beginning its advance on the 17th August, entered Brussels on the 20th *idem*, whilst von Bülow's Army delivered an attack on the Sambre on the 21st *idem*.

Colonel Feyler points out that the attack on Liège on the 4th August—the third day of mobilization—which brought about a disclosure of the German plans does not fit in with a scheme which provided for a general deployment to begin on the 17th *idem*—the 16th day of mobilization—nor with the collision at Mons on the 23rd *idem*—the 22nd day of mobilization. For the surprise to have been a complete success, the order and dates of the events in question should have been as follows:—*Coup de main* securing passages of Meuse, 5th to 7th August; general deployment of the German Army, 8th *idem*; occupation of Brussels, 11th *idem*; arrival of von Klück in Lille region, 14th or 15th *idem*, *i.e.*, a week before arrival of British Army in the neighbourhood of Maubeuge.

It is stated in the original article that the dates just set out are those contained in the programme which had been drawn up by the Great General Staff.

Colonel Feyler points out that having regard to the facts that the two battalions of 21-cm. mortars attached to the attacking German columns had to be brought into action against the N.E. forts of Liège, and that the 34th Brigade (the one on the most northernly route) had to lend a battalion to the 27th Brigade, it is evident that the *coup de main* against Liège was not so successful as the Berlin authorities have claimed it to be. That the stroke against Liège miscarried is also to be gathered from the fact that the German right wing was not set into motion for the

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invasion of Northern France immediately on the completion of the concentration of the German left wing in Lorraine. It has to be borne in mind that, in spite of the difficulties caused to the French 7th A.C. by reason of the want of success attending its operations in Alsace, General Pau's Army was ready to strike on the 13th August. In Lorraine, Dubail was ready on the evening of the 12th *idem*, and Castlenau's Army actually began its offensive movement on the 14th *idem*. The German Armies in Lorraine must have been ready to meet the French on the above dates. In view of the foregoing situation, it would indeed have been a singular thing if, in spite of the fact that the German right wing had to advance from 100 to 170 km. (*i.e.* about 60 to 100 miles) to come on to the same strategic front as the left wing, the plans of the Great General Staff had not provided for the mobilization of the German right wing being completed at least as early as that of the left wing. Indeed, if the German Armies in Lorraine were ready to assume the offensive on the 13th or 14th August, as were the French Armies, then the German Armies intended to march into Belgium should have been ready to commence their advance on the 8th or 9th *idem* at latest.

The German statement that von Emmich's Brigades were sent against Liège at their peace establishment cannot, says Colonel Feyler, be accepted as true merely because it appears in an official document. Had these brigades been pushed forward, as stated, before being made up to War establishment, they would have been lacking not only in their full complement of men, but also in certain details of equipment. It should not have proved beyond the capacity of the Great General Staff to make up six brigades to War stablishment in *personnel* and to provide them with the necessary additional equipment and transport *in an emergency* in a locality such as Aix-la-Chapelle.

In making the statement that the *coup de main* against Liège was undertaken by brigades at peace strength, the Great General Staff, Colonel Feyler points out, lays itself open to severe criticism. In acting thus, it not only ran the risk of prematurely disclosing the German plan of campaign, but it failed to adopt the most adequate measures to secure the success of the enterprise contemplated. The Germans had the choice of alternatives ; they could either have attacked with a sufficient force, and thereby disclosed the importance of the task assigned to the right wing of their army, but with the advantage that they would have broken through the obstacle in their way with the minimum loss of time, or, on the other hand, they could have attempted to conceal their plans by pushing forward a relatively small force only, but in this case they ran a serious risk of the failure of their plans. They adopted the latter course ; they do not appear to have appreciated, at their true value, the risks involved in the plan of campaign prepared by the Great General Staff. The German plan for the invasion of France was faulty in conception both from the point of view of strategy, as well as that of diplomacy ; the German armies had to mark time, whilst a way was being opened for them into Belgium, and the measures taken to conceal Germany's war-like intentions provide ample evidence to prove the bankruptcy of her diplomacy.

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Training Centre of the Swiss 1st Division.

A brief description is given in the original article of the six weeks' course of training provided for the 1917 and 1918 recruits called up for service with the Swiss 1st Division during the current year. The training given to these recruits is based on the methods adopted in the French Army. The author of the original article states that, although good results are being obtained, much has still to be done to put the training of the infantry of the Swiss 1st Division on a thoroughly sound footing. Sufficient is not being done, it is suggested, for providing instruction for the specialists, in the case of officers as well as of other ranks. The formation of musketry and bombing schools, and the institution of courses in gymnastics and bayonet fighting for the specialists is strongly advocated in the original article. It is urged that the period of instruction at the training centre should be extended to sixty-five days.

The Peace Question.

Colonel Feyler contributed an article on "A Durable and Immediate Peace" to the number of the *Revue* for May last (*vide R.E. Journal* for July, 1918). The article in question was based on a pamphlet by the late M. Ragnar Paijkull-Sturzenbecker, entitled *Droit au but. Les conditions essentiels pour une paix durable.* The number of the *Revue* under notice contains a reply to Colonel Feyler written by M. Paijkull-Sturzenbecker very shortly before his death, which occurred suddenly. The author of *Droit au but*, in his reply, states that although he is flattered that the issue of his pamphlet had prompted Colonel Feyler to contribute a long article to the *Revue*, still he much regrets that the Colonel did not review this pamphlet. He expresses the opinion that he and Colonel Feyler have approached the same subject from different points of view; there is nothing remarkable therefore in the two writers having arrived at conclusions which do not agree.

M. Paijkull-Sturzenbecker states that, although, in his pamphlet, he does not take the side of either of the belligerent groups, he has made it clear that he in no way seeks to minimize the enormity of the crimes committed by Germany, nor does he make any attempt to excuse her immoral acts. His object was merely to look for some common ground, which would afford a suitable starting point for an agreement whereon the foundations of a future peace could begin at once to be laid.

It is clear from M. Paijkull-Sturzenbecker's reply to Colonel Feyler that the conflict in the views held by these two gentlemen on the subject of the present War and the means for securing a permanent and durable peace was sharp, and probably irreconcilable. The reply is too long to reproduce here *in extenso* and it, unfortunately, does not lend itself to condensation.

Notes and News.

Switzerland.—The somewhat heavy mortality among the young soldiers, who have succumbed during the influenza epidemic prevalent in Switzerland during last spring, has unfortunately resulted in an extremely violent Press campaign being directed against the Director-General of the Swiss Army Medical Service.

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A spirit of unrest seems to be prevalent everywhere. Switzerland has been, in recent times, troubled by the formation of "*fédérations de soldats.*" A general order has recently been issued forbidding the formation of such associations; fear is expressed, however, that professional agitators and the "enemies" of Swiss military institutions will not be deterred from carrying on, clandestinely, their nefarious work of undermining the discipline of the Swiss soldier. This danger can best be combated, it is urged, if the military authorities are watchful and take the necessary steps to prevent the many petty annoyances to which soldiers have been subject, and which were the true cause of the "*fédération de soldats*" coming into existence.

It is stated that the Swiss cavalry is living in a state of "splendid isolation"; the War and its lessons seem to have no existence for this arm of the Swiss Army. No Cavalry Brigade Commander has, it is said, taken any official part in the tactical exercises of the combined arms which have been carried out since the Swiss Army was mobilized. The modern conditions of war, it is suggested, still require to be brought home to the Swiss Cavalry.

Portugal.—A special correspondent contributes notes from the Portuguese front in France. During the recent German offensive the Portuguese troops held a part of the line in the neighbourhood of Neuve Chapelle and were forced back to the Lys.

A special reference is made to the work of the Portuguese Artillery, which suffered somewhat heavily during the German advance.

What was known as the *secteur calme*, part whereof was held by the Portuguese, was during the German offensive the scene of much strenuous fighting. The Portuguese troops are naturally proud that it fell to their lot to bear their share of the brunt of the German attack.

A *Bulletin Bibliographique* concludes this number of the *Revue*. Notices are published relating to works, which deal with certain important Belgian questions; *inter alia*, M. Passelecq's *La question flamande et l'Allemagne*, M. Passelecq's *Le testament politique du Général von Bissing* and M. von Langenhove's *La volonté nationale belge en* 1830.

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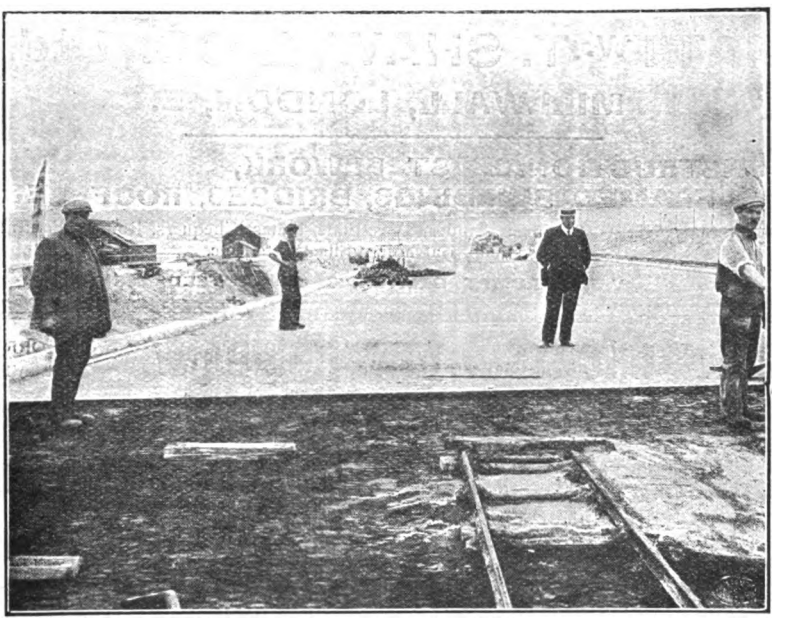

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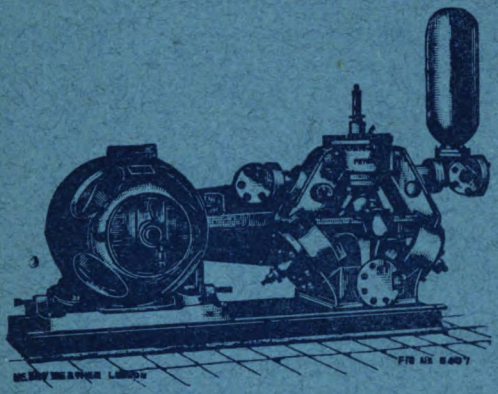

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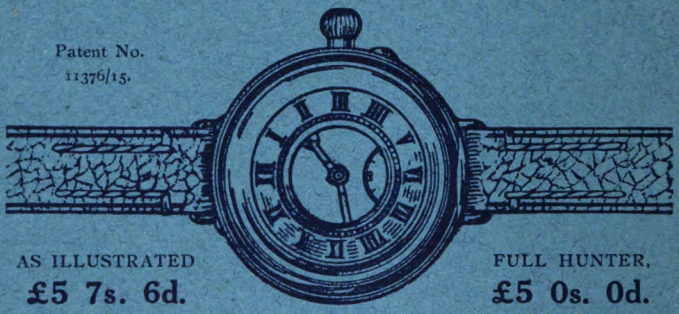

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Authors alone are responsible for the statements made and the opinions expressed in their papers.—(G. 5281).

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elsewhere. In the first place water from Kantara was brought in fanatis* on camels. As the railway progressed it was taken by rail and siphoned into canvas or iron tanks erected beside the railway. Latterly a 6-in. pipe line to Romani and Mahamduja was laid and later still a 12-in. pipe line to El Arish and Rafa, water being pumped from Kantara by relays. The water dumps in which the train-borne water was stored consisted usually of 2,300 gallon white canvas tanks and tanks made from proofed 30-ft. by 30-ft. green canvas sheets. The water was siphoned from these tanks into fanatis in which it was carried on camels to the troops.

Though not suitable for troops drinking, the slightly brackish water was used almost entirely for watering horses and camels, numbers of wells being dug by the R.E. for this purpose. The railway was built in stretches of from 5 to 10 miles and at the end of each stretch a drinking-water dump was formed and wells sunk for watering horses and camels near by. The usual procedure adopted was for a small party of R.E. with a Norton tube to go ahead of the railway, protected by mounted troops, and search for water. When water was found a company (or more) R.E. were sent forward to dig wells. When sufficient water was developed the Norton tube party would go on to where the next drinking-water dump was to be and so on. This slightly brackish water may be found either at the foot of a high sand dune whose steep side faces north, or else at the edge of a sabket (or salt marsh). In the former case a grove of palm trees is often to be found in such a position. If this is so the best place to sink a well is just clear of the grove preferably on the side of the sand dune. The best water was to be found where there was no palm grove. The water, it seems, is stored up in the sand dune from winter rains and possibly also from the dews which are very heavy in summer.

In the latter case the site for a well has to be carefully chosen by trial and error with the Norton tube. The fresh water, stored up in the rolling sand dunes at the side of the sabket, appears to be held up at its edge by the denser salt water and only to mix with it very slowly. The level of the fresh water is appreciably higher than that of the salt water in the sabket. At Abu Hamra near Katia the difference in level was measured and was found to be 5 in. in a distance of about 40 yards.

A medical officer at first and latterly a chemist (N.C.O. or private, R.A.M.C.) was attached to the field company which was searching for water for the purpose of testing the water for salinity by means of a simple titration with silver nitrate. It was found that the average horse would drink water of salinity up to 600 or 700, that is with 600 to 700 parts of salt per hundred thousand. A camel will take water with a salinity of 1,500 or even more if very thirsty.

* A fantasse (plural, fanatis) is a rectangular tank of galvanized iron or copper, containing from 10 to 15 gallons of water, used for carrying water on camels.

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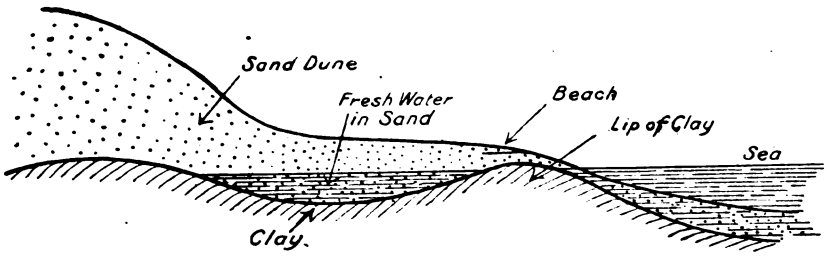
El Arish to Gaza.—The sand dunes extend along the coast from Kantara to Jaffa. Between El Arish and Jaffa there is a clay strata immediately below the sand appearing as outcrops in many places. In this district the rainfall is much more considerable than in that dealt with above. The rain water filters through the sand and is held up by the clay and consequently practically fresh water may be found at varying depths almost anywhere in this strip of sand dunes. It is sometimes found, collected no doubt in cups of clay, quite high up in the sand dunes, a good example of this being an old native well in the dunes near Rafa.

The most remarkable feature in this district is the presence of fresh water on the beach. Perfectly fresh water, salinity sometimes as low as 6, may be found at depths of 5 ft. to 15 ft. anywhere along the beach within 50 or 100 yards of the sea. The following sketch gives the probable explanation of this :—



Section through Beach.

A lip has been formed on the edge of the clay strata by the action of the sea making a cup of clay into which the rain water from the sand dunes drains. This lip prevents the sea water mixing with the fresh. Its position varies a few yards and in places there are " faults " in it. Consequently the sites of wells have to be chosen very carefully. Wells should not be sunk too near to the sea or a fault in the clay may let in the sea water and spoil them. This actually happened at El Arish and again at El Khanuba. In each case water of salinity less than 100 (fit for human consumption) was obtained by digging wells about 40 yards from the sea. These gradually became more and more brackish and eventually were unfit even for camels (salinity about 2,000). On the other hand, the sand dunes rise steeply from the seashore at an average distance of 50 to 100 yards from the sea, so that wells cannot be sunk very far from the sea owing to the prohibitive depth of the water.

The Norton tube was used again very extensively in testing the water in this district. At El Khanuba for instance a systematic survey was made with its aid, the depth to water level and the salinity of the water being taken at intervals along the beach and in lines parallel with the shore. Wells were then sunk at the most suitable points for troops drinking, horses and camels. Many stone wells made by natives were found on the beach.

Inland water is to be found at a much lower level, that is, below the

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clay strata. At Rafa for instance water level was 40 ft. below ground level on the plain. In many places in this district wells up to 120 ft. deep were found.

Apart from these two sources water was obtained between El Arish and Gaza.

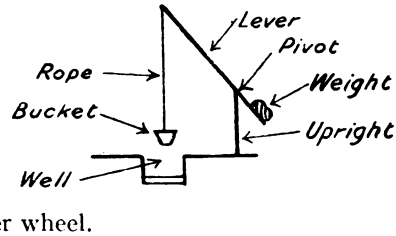
(1). From the lake at Deir el Belah. This lake very seldom completely dries up. It was used largely during the first and between the first and second battles of Gaza for watering animals, while the wells, of which there are numbers round about it, were used for troops drinking. These wells are permanent sources of supply and water was pumped from them through a pipe line to water dumps immediately behind the front line after the second battle of Gaza.

(2). From the Wadi el Arish. At the mouth the water level is very near the surface and the native wells, which are mere sumps just above the bed of the Wadi and are used for irrigation purposes, were the main supply for watering animals during the occupation of El Arish. Shadufs* both native and improvised were used largely here for raising the water as in all places where the depth to water was not great.

(3). From the Wadi Ghuzze. Wells and sumps dug in the Wadi bed were used extensively for watering troops and animals during the time of preparation for the third and last attack on Gaza. The water is on the surface near Shellal and from there flows in a gravel stratum beneath the clay till it reappears on the surface near the mouth. It is in places as deep as 50 ft. below the level of the Wadi bed. When the rainy season approached many wells were sunk on the banks of the Wadi to replace those in the Wadi bed as they would have been inaccessible during the floods. These wells were never needed by the division as the Wadi Ghuzze never flowed till after the capture of Gaza.

Gaza to Ramleh.—The first source of water used during the pursuit after the capture of Gaza was the Wadi Hesy. In the mouth of the Wadi running water was found and this together with sumps dug on the beach was used for watering the division. During the advance from here to the foot of the Judean Hills deep wells were the sole source of supply. Many were found undamaged with saquias†

* A native erection, consisting of a pole with a bucket attached by a rope and pivoted on an upright, used for raising water thus :—



† A native water wheel.

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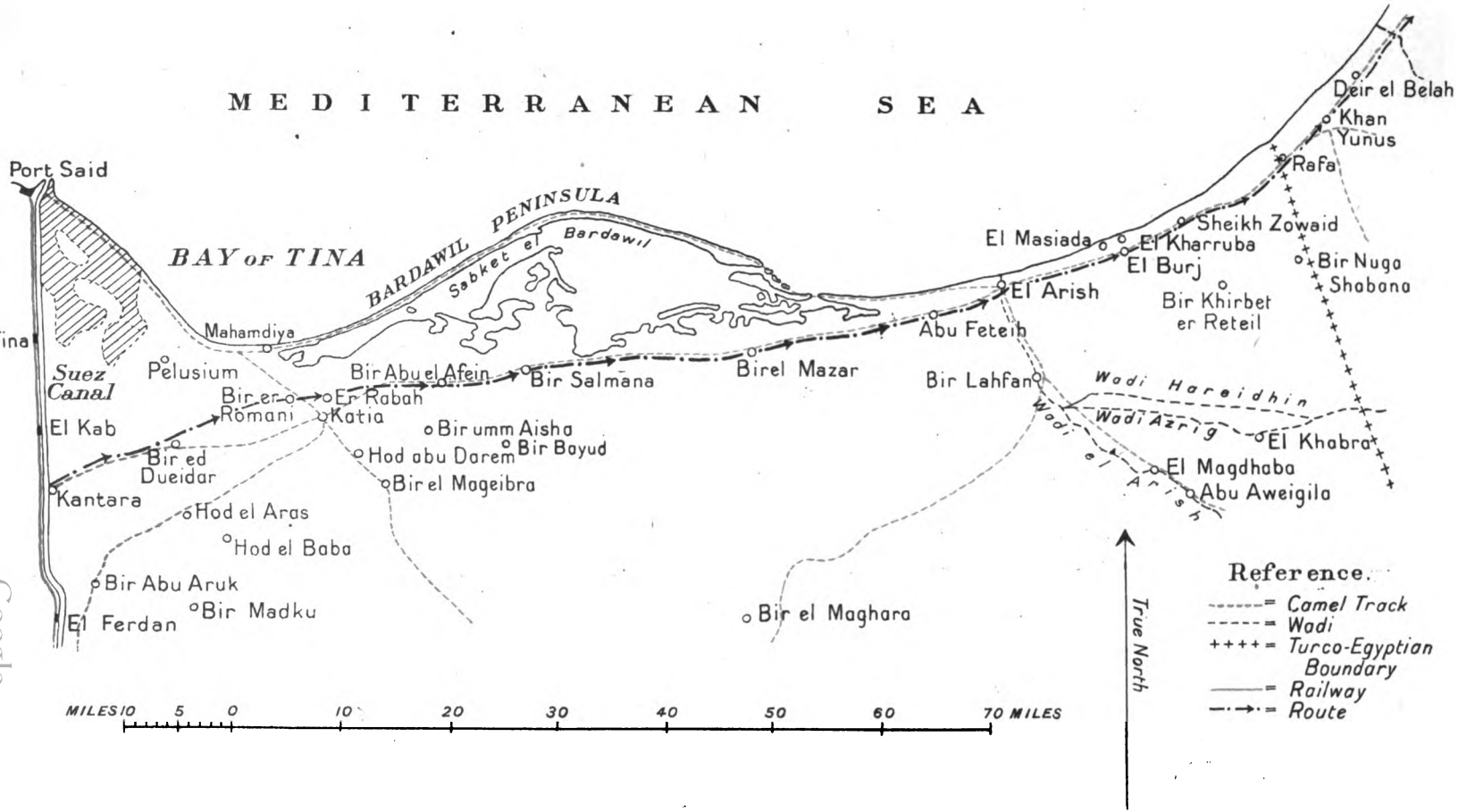
NORTHERN SINAI.



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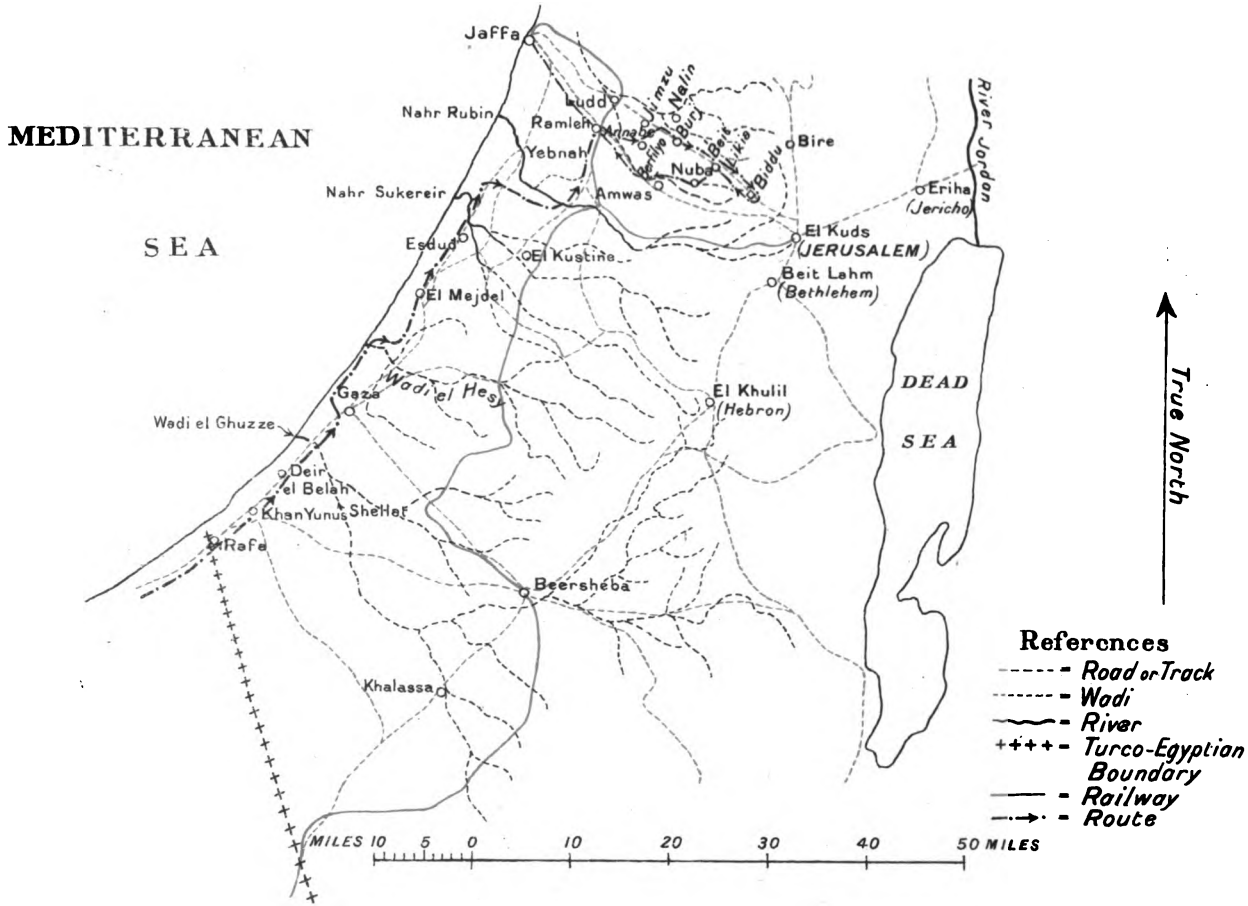
SOUTHERN PALESTINE.



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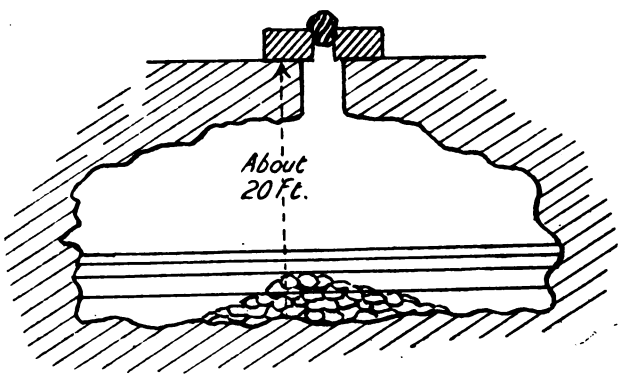
fitted for use with horses or manual labour and saquias and deep well pumps with power plant. In the orange groves about Ramleh many deep wells with power pumps were found undamaged and used for watering troops and animals, their normal use being the irrigation of the orange groves. Many of the engines were in very bad condition; for instance at the Jewish colony of Katrah the brass had been removed from the bearings and wooden bearings substituted. During the running of the engine these had constantly to be replaced.

Judean Hills.—On reaching the Judean Hills the problem of water supply assumed a very different aspect. As yet no rain had fallen. The country is very rocky and the main source of supply during the march towards Jerusalem was rain water stored from the previous winter in cisterns hollowed out of the rock. These cisterns are apparently in many cases natural, having been merely improved by the natives. They are very large and irregular in shape though all have a bottle neck generally corked by a large boulder thus :—



The depth to the bottom is usually about 20 ft. so that the lift and force pump can conveniently be used. A pile of stones is generally to be found in the middle immediately beneath the opening, accumulated no doubt by natives dropping stones in to see if the cistern is empty. Unless this fact is borne in mind one is very apt to misjudge the amount of water the cistern contains. The greatest care had to be taken of the water during this march as the cisterns very rapidly became exhausted.

On the march back to Ramleh a deep well was used at Nuba and a well fed by a spring was found at Kubab. This had a very good yield and supplied the wants of many troops for all purposes.

Jaffa and the Auja.—In and around Jaffa many deep wells were found mainly in the orange groves and when the line was pushed across the Auja, that river supplied water for animals while shallow wells on its banks, normally used with saquias for irrigation purposes, were the main supply for troops drinking.

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THE STORY OF THE CANADIAN EXPEDITIONARY FORCE.

ON Monday, October 14th, Canadians celebrated the Fourth Anniversary of the arrival in England of the First Canadian Troops after the outbreak of War in 1914. We have been favoured by the Historical Section of the Canadian War Records Office with accounts of the work of the Canadian Force from the arrival of the 1st Division to the Fighting for Cambrai. From these the following extracts are made, and which will be read, we are convinced, with great interest and sympathy by the Corps of Royal Engineers.

The Record of the Canadian Expeditionary Force is remarkable, both in regard to its steady growth and the engagements in which Canadian Troops have taken part. Its growth is best recorded in the following table, which has been compiled from the latest official figures :—

Regular Canadian Troops at outbreak of War ...	3,000
Number of First Contingent	33,000
Canadian Soldiers sent overseas up to September 1st, 1918	400,000
Troops in training	60,000
Canadian Soldiers killed in action	50,000
Casualties ... ... over	175,000
Wounded returned to the front	40,000
Returned to Canada	50,000
Number who have received decorations ...	10,000
Awarded the Victoria Cross	40

The First Division went into training on Salisbury Plain about the middle of October, 1914, and sailed for France on February 9th, 1915. The Canadians arrived in Flanders in time to bear the brunt of

The Second Battle of Ypres (April, 1915).—A terrible experience, which culminated, however, in a German defeat and the winning of much glory for Canada. Since then their fighting record may be briefly summarized.

Festubert (May, 1915).—The initial stages of the Aubers Ridge offensive. The Canadians, attached to the First Army, continued the sanguinary fighting for La Quinque Rue, K5, and the Orchard.

Givenchy (June, 1915).—The Aubers Ridge offensive continued from the South. How the Canadians renewed the attacks upon Rue d'Ouvert, Chapelle St. Roch, and Violaines

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Loos (September, 1915).—The Canadians played a small part only in this battle, but by artillery work, minor attacks, and a simulated offensive prevented the movement of German reserves.

St. Eloi (April, 1916).—Throughout the whole month the men of the 2nd Canadian Division fought a terrible and inconclusive battle for the possession of the mine craters before the village.

Sanctuary Wood (June, 1916).—The third great German attempt.

Hooge (for Ypres).—On June 2nd the enemy attacked and pressed our men back, but on the 13th the Canadians counter-attacked and regained the lost positions.

The Somme: Courcelette (September, 1916).—Here the Canadians gained a brilliant victory, capturing the village and penetrating beyond their final objectives.

Regina Trench (October—November, 1916).—The scene of some of the bloodiest fighting of the War. Regina Trench was captured by the 4th Canadian Division on November 11th.

Vimy Ridge (April, 1917).—The Germans deemed this position impregnable. It was captured by the Canadian Corps in one of the most carefully-conceived and brilliantly-executed enterprises of the War.

Hill 70: Lens (July—August, 1917).—In many weeks of close fighting the Canadians prepared the way for the capture of Lens. The final assault was postponed by the Passchendaele operations.

Passchendaele (October—November, 1917).—There were four distinct battles in this operation, and the final attack upon November 10th gained the Canadian Corps the whole object of the offensive.

Villers-Bretonneux (March, 1918).—At this point the Canadian Motor Machine Gun Batteries materially assisted in the first real check to the great German advance.

Amiens: Monchy: Cambrai (1918).—The series of battles which resulted in the final check of the German armies has not yet been properly recorded. The victory of Monchy is assured. The fighting about Cambrai is undecided, though there is no doubt of the final issue.

Apart from her fighting men Canada has furnished various special corps which have proved of inestimable value to the British Armies. The Canadian Forestry Corps has brought the craft of lumbering to Europe, and at times has supplied the armies of three countries with necessary timber for the thousand-and-one purposes of War.

The Canadian Corps Salvage Companies have supplied numerous munition factories behind the lines with raw material—raw material gathered from the battlefield. And on the whole of the Western front the Canadian Railway Troops have been employed, handling French, Belgian, English and Canadian munitions and supplies, pushing their railways forward through mud and shell fire, and delivering the goods with the best of them.

* * * * *

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Canadian Captures.—In the Cambrai battle since September 26th, 1918, the Canadian Corps has captured 37 square miles and 15 villages with the greatest depth penetration of 8½ miles. The prisoners captured total 7,139 with 201 guns and nearly 1,000 machine guns and trench mortars.

From August 8th to October 2nd, the Canadian Corps captured the following:—26,630 prisoners, 501 guns of all calibres, including many heavies, over 3,000 machine guns and mortars, 69 villages and 160 square miles with a greatest penetration in any single operation of 14 miles, this being before Amiens. During this period the Corps has engaged 47 enemy divisions, of which 40 were fully and seven partially engaged.

* * * * *

THE CANADIAN RAILWAY TROOPS.

Early in February, 1915, the Canadian Pacific Railway was asked by the Minister of Militia to furnish plans of a Railway Repair Force for Overseas service. These plans were prepared promptly, and on the 24th the C.P.R. was instructed to organize two military Engineering Railway Corps for service abroad. The force was mobilized at St. John, under the command of Lieut.-Colonel Ramsey, and arrived in England on June 25th, 1915.

Expert railwaymen were badly needed in Flanders and the force was held in England a few weeks only. In August the men reached Belgium, and were employed under the orders of the British Mission to the Belgian Army. During the next two months a great deal of field engineering was carried out for the 2nd and 4th Divisions of the Belgian Army, and also much construction work was done for the Royal Naval Siege Guns near Nieuport. In October the unit returned to England for transfer to another front.

Early in November, however, the railwaymen were back in France, and from that time to this there has been no slackening in their labours. Truly marvellous work has been accomplished, and it would be difficult to over-estimate the influence of the Railway Troops upon the successful operations of the Canadian Corps.

In February, 1917, the Railway Construction Corps was reorganized and the three Construction Battalions became the 1st, 2nd, and 3rd Battalions Canadian Railway Troops. Before the reorganization the Canadian railwaymen had laid 127 miles of track and put in 410 switches. Since then these totals have probably been doubled.

It would be hard for a civilian engineer to realize the problems that beset the army railwayman. Sometimes a railway is pushed forward for miles over a sea of mud and water, where firm ground cannot be reached above a depth of ten feet. The labour required, of course, is enormous—at times the Canadian Railway Troops have had 7,000 men working under them. But to a great extent the work is

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completed by the railwaymen themselves, commonly under shell fire, and frequently with machine-gun and rifle bullets about their ears.

So the work goes on. The infantry advances and behind the battalions follow the guns, and about them the Railway Troops, feeding them with shells and laying tracks for further progress. Weary, strenuous work, and work without much glory—but when the infantrymen see a sector supplied by a light railway, and know how many repeated miles of loaded stumbling it saves them, the Railway Troops come into a little of their own.

* * * * *

THE CANADIAN CORPS SALVAGE COMPANY.

The Canadian Corps Salvage Company was established on September 1st, 1916, when the Corps moved to the Somme area. It was not in full working order, however, until about two weeks after arrival, though meanwhile steps had been taken to collect material and place it on Dumps ready for shipment. During the operations in the Ypres Salient a certain amount of Salvage work was done under Divisional supervision, but during that time there was no organized Salvage Company.

Later, when the Salvage scheme was in working order, the operations were controlled by the Corps Salvage Company, under the command of Lieut. H. A. Judd, 2nd King Edward's Horse. This *personnel* was from time to time supplemented by other units supervized and directed by the Divisional Salvage Officers.

The work of the Salvage Company is a great deal more interesting than one would imagine, and the actual cash equivalents for the reclaimed material form a really stupendous total. Nothing is too large or too small to be dealt with; from horseshoe nails to a damaged tank, all is grist to the mill of the Salvage Officers.

And the value of the work is by no means a matter of theory. For instance, directly after the Vimy operations the Salvage men began to clear the battlefield. One cannot begin to enumerate the lists of war materials recovered, but the value of the total was over £220,000. A truly remarkable saving. Transport, of course, is a difficulty, but brains have simplified this difficult problem to a great extent. Biscuit tins, for example, are valuable, numerous, and very unwieldy. But knock away the solder which holds the sides together and they become plain sheets of tin, easily handled and compact for disposal. It is unnecessary to mention that the solder is salved also.

Munition works behind the lines are supplied with raw material. Units in the front line are frequently issued with immense stocks of salved ammunition—a saving here not only in money and material, but also in transport, time and labour. It is impossible to do justice to the Salvage Company in such limited space, but its members require no praise. They simply point to results.

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TRANSCRIPT.

THE CORRECT PROPORTIONING OF CONCRETE.

By H. C. JOHNSON and W. KINGSTON, B.E. (University College, Cork).

(Reproduced from the monthly Journal *Concrete and Constructional Engineering* of September, 1918, by the kindness of the Editor).

THE following series of tests was undertaken with a view to showing that the common practice of specifying for concrete such proportions as 1 : 2 : 4, 1 : 3 : 6, etc., is not practical and is unscientific, since it does not take into consideration the adaptability of the grading to the production of the best possible concrete with the given aggregates.

There are three facts about 1 : 2 : 4 concretes which suggested the lines on which one should aim at proportioning concrete :—

(1). The amount of cement in a finished volume of 1 : 2 : 4 concrete varies, with different aggregates, by as much as 30 per cent. This has originated the erroneous idea that gravel is not so good as stone as an aggregate, while the fact is that a greater volume of concrete is produced by using gravel. Hence gravel has often been rejected in favour of stone as an aggregate, when, if given an equal chance, it would have made an equally strong, more workable and more impervious concrete.

(2). The proportion of sand to large aggregate in 1 : 2 : 4 concrete is always the same no matter what kind the aggregate is. Now, tests have proved that the grading being satisfactory, the coarser the aggregate the stronger the concrete. The reason for this seems to be that the surface area of small aggregate is greater than that of large, and therefore more cement is needed in uniting these small particles (which are united in themselves in the large aggregate). Therefore, it seems unreasonable to introduce into a concrete more of this small aggregate than is absolutely necessary.

(3). 1 : 2 : 4, 1 : 2½ : 5 and similar concretes vary in density because no attempt is made to obtain a concrete of the greatest weight per cu. ft. for a given set of aggregates. The result of this is a weaker and more porous concrete, affording less protection to the steel in reinforced work.

From these facts it was decided to try to improve on the old method of proportioning by making concretes having :—

(1). Equal percentages of cement in the finished volume of concrete.
(2). Least possible amount of the small aggregate consistent with the production of a workable concrete.
(3). Greatest density.

This is called " corrected concrete," and, for comparison, a series of ordinary 1 : 2 : 4 concretes was made with the same aggregates.

From a previous series of experiments it was found that the *average* amount of cement in 1 : 2 : 4 concretes is about 21 per cent., which it was decided to use for all the " corrected concretes."

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Sand is introduced into concrete to fill the voids in the large aggregate and to make the mixture workable. The voids in the large aggregate are just filled when the weight per cu. ft. of the concrete ceases to increase, and any more sand only spreads the mass and weakens the concrete, and is unnecessary provided the concrete is workable.

Method of Proportioning.

The method adopted in finding the correct proportions was therefore as follows:—

It is needless to say that previous knowledge of mixtures and the results to be expected are very necessary in arriving quickly at the correct proportions. The following table shows, step by step, the procedure adopted in finding the proportions for a 20 per cent. mix. It will be noted that the quantity of cement to be contained in 1 cu. ft. of finished concrete (20 per cent. of 1 cu. ft.) is introduced at the start and none added later, but in the case of the aggregates a smaller quantity than is required in the finished concrete is taken, and additions are made later as is thought necessary.

Take 1 cu. ft. pail and measure out 0·8 cu. ft. of gravel and 0·25 cu. ft. of sand. Weigh out 0·10 of 1 cu. ft. of cement, 10 lb. (reckoning cement = 100 lb. per cu. ft.). Mix in the usual way with water, and find volume and weight of resulting concrete. This will not produce 1 cu. ft., so turn out and add sand until a workable concrete is obtained, and if this does not fill the pail add large aggregate, mixing and measuring on each addition until the 1 cu. ft. is arrived at. We now have 1 cu. ft. of concrete containing exactly 20 per cent. cement, and having the smallest necessary amount of small aggregate.

Example.

Gravel.	Sand.	Cement.	Vol.	Weight.	Wt. cu. ft.	Remarks.
cu. ft.	cu. ft.	cu. ft.	cu. ft.	lb.	lb.	
0·4	0·125	0·1	0·435	62	144	Not workable, therefore add sand 0·025 cu. ft.
0·4	0·15	0·1	0·460	67	145½	Still unworkable, add sand 0·025 cu. ft.
0·4	0·175	0·1	0·488	71	145½	Workable, but not to volume, add gravel 0·025 cu. ft.
0·425	0·175	0·1	0·502	73½	146½	Correct.
4¼	1¾	1	are correct proportions.			

Granulometric Analysis of Large Aggregates.

Percentage by Volume Retained on Sieves.

Sieves.	Youghal Gravel.	Inniscarra Sandstone.	Newbridge Gravel.	Cork Limestone.
¾ to ⅝	7	2·5	1·8	9
⅝ to ½	10	10	10	32
½ to ⅜	17	17	14	22
⅜ to ¼	42½	38·8	38	8
¼ to ⅛	35½	39·5	41	39
Total	112	107·8	104·8	110

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GRANULOMETRIC ANALYSIS OF SMALL AGGREGATES.

Percentage by Volume Retained on Sieves.

Sieves.	Wicklow Sand.	Leighton Buzzard Sand.
$\frac{1}{4}$ to $\frac{1}{8}$	0	0
$\frac{1}{8}$ to $\frac{1}{16}$	0	1
$\frac{1}{16}$ to $\frac{1}{32}$	0·3	14·3
$\frac{1}{32}$ to $\frac{1}{50}$	38	41·6
Passed $\frac{1}{50}$	62·5	45·8
Total ...	100·8	102·7

NOTE.—These percentages are based on the original volume of the aggregate. When separated into parts by the sieves the volume got by adding the parts is greater than the volume of the original aggregate, and the greater this volume the better the grading.

MATERIALS.

Large Aggregate.—The large aggregates used were :—

Youghal gravel (sandstone).
Inniscarra stone (sandstone).
Newbridge gravel (limestone).
Cork stone (limestone).

The Youghal gravel was taken from the beach at Youghal and passed through $\frac{3}{4}$-in. and held on $\frac{1}{8}$-in. sieve. This is a well-graded gravel of old red sandstone.

The Inniscarra stone was taken from the crusher and screened on the $\frac{3}{4}$-in. and $\frac{1}{8}$-in. sieves. This is a hard green sandstone which breaks with sharp angles.

The Newbridge gravel, as obtained from the pit at Newbridge, co. Kildare, is a uniform-sized black limestone almost all passing $\frac{3}{4}$-in. sieve.

The Cork stone was hand broken. It is a well-graded hard crystalline limestone ($\frac{3}{4}$ in. to $\frac{1}{8}$ in.).

The granulometric analysis of these are shown in the table.

Fine Aggregate.—The fine aggregate used was :—

Wicklow sand.
Leighton Buzzard sand.

The Wicklow sand was a very fine clean quartz sand.

Leighton Buzzard sand was the run of the pit, and medium sized. The granulometric analysis is given in the next table.

Cement.—The cement used was a mixture of two brands :—

South Wales Portland cement.
Irish Portland cement (Magheramorne, co. Antrim).

In order that the mixture might be as uniform in quality as possible it was given 250 turns in the Olsen " Rattler " stone-testing machine.

The strengths of the separate and combined cements are as follows :—

	Fineness		Paste.		Mortar.		Per cent. Water.	
	76	180	7d	28d	7d	28d	Paste.	Mortar.
South Wales ...	0·2	7·47	650	715	364	430	21·25	8·33
Magheramorne	0·21	8·67	470	620	233	400	22·4	8·5
Combined ...	—	—	545	670	286	417	—	—

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Number of Test Specimens.—This gave four large aggregates, two sands and one cement, from which eight batches of "corrected" and eight batches of 1 : 2 : 4 concretes were made, each batch consisting of six 6-in. cubes and six cubes of 10 sq. in. face, giving 198 specimens.

Mixing.

The concrete was mixed in a Ransome batch mixer. The weight per cu. ft. of all materials was first found, and all volumes were then measured by their corresponding weights to eliminate the errors of volume measurement. All the aggregates necessary for a batch were placed beside the mixer, and the mixer was then started. The large aggregate was put in, and 10 lb. of water was added, and afterwards the sand and cement. Additional water was then added, and after five minutes the batch was discharged into a pan. A little more water was put in to clear the mixer, and after a few turns was discharged into a pail. Some of this was put into each mould to get a better surface on the specimen, and the concrete was then scooped in. The concrete was of such a consistency that very little ramming was necessary to bring water to the surface. The trowel was inserted between the concrete and the face of the mould to bring the finer material to the face of the specimen. The finished volume of the concrete and the weight of water used were ascertained, and careful note was taken of all operations. The following is an exact copy of an entry in the book during one operation :—

"Batch B1 ... ... Newbridge gravel.
4 : 2 : 1 concrete with fine sand.
Quantities required :—
Gravel, 73 lb. 11½ oz. (0·76 cu. ft.).
Sand, 35 lb. ¾ oz. (0·38 cu. ft.).
Cement, 19 lb. 0 oz. (0·19 cu. ft.).
The mixer was started at 11.40, and the gravel and water were put in. The sand and cement were introduced at 11.41, and additional water was then added to bring to the proper consistency. The mixer was discharged at 11.46. The mix was fairly wet, and very easily worked.
Finished vol. ... ... 0·87 cu. ft.
Water used ... ... 12·33 lb."

Curing of Specimens.

The specimens were allowed to remain in the moulds for 48 hours, after which they were taken out and immersed, two deep, in water in a large tank, where they remained for seven days. They were then taken out and laid singly on the floor of the laboratory so that five faces of each cube were exposed to the air. This procedure is quite essential to secure uniformity in the shape and condition of the specimens.

Testing.

When the specimens were to be tested each cube was measured and weighed. It was then found that the faces of the 6-in. cubes, cast in wooden moulds, were not quite flat, so that it was necessary to grind down the surface by constant rubbing on the floor until a true face was obtained. The cubes were then placed, without packing, on a spherical seat in the 200,000-lb. Olsen testing machine and tested to ultimate load.

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Result of Tests.					One Month.			Three Months.		
Proportions.	Materials.	Percentage Cement.	Percentage of Water.	Weight per cu. ft.	Strength. lb. per sq. in.	Percentage increase.	Per cent. inc. per 1 per cent. Cement.	Strength. lb. per sq. in.	Percentage increase.	Per cent. inc. per 1 per cent. Cement.
1 : 2 : 4	Sandstone gravel and	21·6	9·4	143½	2,400	—	*	3,560	—	—
1 : 1·43 : 4·5	fine sand.	20·8	9·2	146	2,575	7·2	11·43	3,375	6·4	9·48
1 : 2 : 4	Sandstone gravel and	20·45	9·2	146	2,640	—	—	3,255	—	—
1 : 1·43 : 4·3	coarse sand.	20·4	9·7	145½	2,292	13·2 dec.	13 dec.	2,970	8·75 dec.	8·54 dec.
1 : 2 : 4	Limestone gravel and	21·85	9·6	142½	2,320	—	—	3,645	—	—
1 : 1·43 : 4·3	fine sand.	20·90	9·3	145	2,890	24·56	30·2	4,020	10·28	15·3
1 : 2 : 4	Limestone gravel and	21·35	11·3	144	2,675	—	—	3,165	—	—
1 : 1·6 : 4·15	coarse sand.	21	9·7	146	3,060	14·3	16·3	3,970	25·4	27·5
1 : 2 : 4	Crushed sandstone and	23·9	11·4	144	2,380	—	—	3,185	—	—
1 : 1·4 : 4·6	fine sand.	20·8	10·3	146½	2,750	15·5	32·7	3,355	5·3	21
1 : 2 : 4	Crushed sandstone and	21·5	9·7	146½	2,920	—	—	3,718	—	—
1 : 1·8 : 4·4	coarse sand.	21·75	11	146	2,730	6·5 dec.	7·6 dec.	3,650	1·8 dec.	3·34 dec.
1 : 2 : 4	Broken limestone and	23·35	10	147½	2,450	—	—	3,110	—	—
1 : 1·72 : 4·75	fine sand.	21	9·7	148½	2,710	10·6	22·85	3,660	17·6	30·9
1 : 2 : 4	Broken limestone and	22·25	9·7	149	2,535	—	—	3,103	—	—
1 : 1·67 : 4·5	coarse sand.	21	9·8	148½	2,490	1·77 dec.	4·03	3,213	3·54	9·7

The above strengths are average values. The percentage of water is the percentage by weight of all dry materials.

* The difference per 1 per cent. cement is got by dividing the strength per sq. in. by the percentage of cement in the concrete and basing percentage difference on this.

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Conclusions.

(1). Arbitrary proportions, such as 1 : 2 : 4, 1 : 3 : 6, should not be used in specifying for concrete.

(2). The quantity of cement should be based on the finished volume of concrete, and be defined as a certain percentage of this.

(3). The aggregates should be tested to find the proportions that will produce the best possible concrete with the specified percentage of cement.

(4). Gravel is as good an aggregate for concrete as stone, if not better, because it requires less sand to make it workable.

(5). In so-called 1 : 2 : 4 concretes lower strength is got with the finer small aggregate.

(6). In concrete proportioned as described, the size of the small aggregate does not make such a difference because less of the finer sand can be used.

(7). In all cases concrete containing the same aggregates gives increase of strength with increase of density.

Editorial Note on the Above.

The article describing the tests which were undertaken by Messrs. H. C. Johnson and W. Kingston, on page 453 of this issue, while not altogether convincing to the practical man, contains a great deal of interesting matter, and it indicates a certain amount of progression which is commendable. We feel, however, that the results and comments are not such as will lead to the abandonment of the 1 : 2 : 4 method of specifying a concrete mix, and while it is perfectly clear that this existing method is not strictly scientific it is eminently practical, and some very conclusive arguments will be necessary before a less practical though more scientific specification is adopted.

Water Plays an Important Part.—Exhaustive tests and investigations as to the ideal proportions for all classes of concrete are absolutely essential, and such tests should certainly form part of the programme of the institute which is devoted to the advancement of the use of concrete, but there are certain points which must not be overlooked if the results are to be absolutely reliable. One of the chief of these is the fact that the amount of water used plays a very important part in the strength of the resulting concrete, and in our last issue we published an article by Professor Duff A. Abrams, which showed in a striking manner that as long as a workable mix was obtained then the less the water used the greater the strength of the concrete.

Now it is interesting to note in the table prepared by Messrs. Johnson and Kingston that in every case the strongest concrete is that mixed with the smallest percentage of water, regardless of the proportions of the cement and aggregate, or whether it was a 1 : 2 : 4 mixture or a "corrected" mixture! In the face of this fact one is rather tempted to consider whether the 1 : 2 : 4 mixture might not have proved the stronger mixture of the two in every case if the percentage of water had been reduced to a little below that used for the corrected mixture. It is certainly curious that the results should be affected in this way, and

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a good case can scarcely be made out for " corrected " concrete unless an increased percentage of strength for the cement used is supported by the fact that the same amount of water was used as that employed for the mixture under comparison. It will also be seen in some examples that the 1 : 2 : 4 mixture was not only stronger but that the corrected concrete showed a percentage decrease in strength. As the values given are average ones it shows that the corrected concrete is not absolutely dependable although based on scientific methods, and, furthermore, the results given seem to show a greater variation than with the practical method. There are other curious features that will be noticed—viz., that the heaviest concrete was produced with a 1 : 2 : 4 mix made up with broken limestone and coarse sand, and yet at the age of three months the concrete gave the lowest value as regards strength of all the 1 : 2 : 4 mixtures! Here is another aspect which must not be lost sight of in connection with these tests, and that is whether the small difference in the percentage of cement between the two classes of mixtures is sufficient to make any real difference in practice.

Percentage of Cement.—It will be noticed that the difference in the percentage varies from about 3 to ·05, and unless some method of measuring the cement in the actual work was adopted which was fool-proof or in some way automatic we are afraid that the variation due to the uncertainties of the human element which enter into the gauging even with accurate gauge boxes will result in a percentage variation of often more than 1 per cent. It is true that where efficient supervision is employed concrete mixtures can be turned out of a uniform nature, but the supervisor cannot stand at the mixer all the time, and by reducing the amount of cement we are allowing a smaller margin for waste, negligence, or indifference. The only two factors which set up a chemical action in the mixed concrete to give a solid material are the cement and the water, and of these one is the most expensive factor to the contractor and the other is the cheapest. Now we do not desire to see cement wasted, but it is certainly necessary to ensure sufficient being used, and there must be some margin for the human element as above-mentioned.

These practical points do not, of course, in any way detract from the value of any results that may be obtained from a scientific point of view, but they should not be lost sight of when it comes to the practical application of such results. If a stronger concrete can be produced with less cement it is the duty of every engineer to protect his client's interests by seeing that he gets the benefit of the saving in cost, and the better material, but he must not run any risks in achieving this result.

Gravel and Broken Stone Aggregate.—With regard to the comparisons which are made in the article between gravel and broken stone as an aggregate, we feel that the reasons put forward for the rejection of gravel by many people do not quite hold good. In actual practice many engineers find it difficult to obtain such a good surface finish with concrete made with uncrushed gravel, as groups of round stones will appear in patches on the face of the work when the shuttering is removed. This is generally caused by the natural tendency of the smooth round

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stones to run together when the concrete is placed in the form, and as the centre of the concrete so often rises slightly above the sides during the actual depositing these stones run down toward the face of the forms, and it involves exceptional tamping to prevent these patches, which are often nearly devoid of cement, from occurring. The same thing occurs at the construction seams caused by the junction of new work with old, as there is not the interlocking tendency to resist the downward movement of the heavy particles as there is with broken stone, and the rough surface of the latter also gives greater frictional resistance to such movement. This condition is aggravated in the case of gravel when the mixture is mixed with a large percentage of water, which makes the concrete liquid to flow around reinforcement. Several instances of the kind have recently been observed, and the results have led architects and engineers to adopt broken stone in preference to gravel.

Importance of Research.—There is a great deal to be done in the investigation of the best proportion and method of mixing for concrete, and it needs a few pioneers, such as Messrs. Johnson and Kingston, to create a lively interest in such matters and make engineers generally realize the importance of the subject, and although our remarks may appear to be critical in some instances we must plead that we, too, are pioneers who have endeavoured to stimulate progress in good concrete work, and as such we criticize in order to assist.

In conclusion, it is highly important, in our opinion, that a part of the research work undertaken in the immediate future should include comprehensive tests of concretes made with all the different classes of aggregates to determine (*a*) the effect of the percentage of water used in relation to the measure or weight of the dry materials ; (*b*) the minimum amount of cement that should be employed with the various aggregates to give concrete having specified minimum strengths ; and (*c*) the best proportions for coarse aggregate, fine aggregate, cement, and water for different materials with the manner of specifying these, and, if possible, some practical recommendations, for the benefit of the person responsible for the work, as to how the gauging and mixing should be done to ensure the specification being complied with.

When this has been achieved we feel that a real step forward will have been made in the direction of the manufacture of concrete in conformity with scientific methods on practical lines.

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NOTICES OF MAGAZINES.

REVUE MILITAIRE SUISSE.

No. 9.—September, 1918.

HEAVY FIELD ARTILLERY BEFORE THE WAR.

Colonel Mayer's article on the above subject begun in the August number of the *Revue* (*vide R.E. Journal* for October, 1918) is concluded in the number under notice. The failure to provide the French Army, previous to the outbreak of the War, with heavy field artillery is attributed by the author of the original article to France's "blind faith in the offensive." The difficulties connected with moving heavy field pieces, bringing them into action in battery formation, and supplying them with ammunition were, he seems to think, overrated. Sight was lost in France, he says, of the fact that the German Army had also unbounded faith in the offensive in war, yet had not hesitated to provide itself with heavy artillery for the purposes of field warfare.

It was to a mischievous doctrine, prevailing in the minds of certain artillery experts, that was due the opposition to the introduction of heavy artillery. These experts had full knowledge, it is asserted, of the information contained in Capt. Glück's book, information which was not in any way made a mystery of or treated as confidential.

It is not alleged that nothing whatever was done in the matter; on the contrary, as always happens in matters of this kind, the force of the opinion of the progressives in France had had some effect; certain measures had in consequence been adopted to compete with the artillery developments across the Rhine.

The 155-mm. (T.R.) field gun otherwise, known as the "Rimailho," after its inventor, was introduced into the French Army as a first step; the design of this gun was based on that of Colonel Deport's 75-mm. field piece. The 155-mm. gun being, when mounted on its firing carriage, too cumbersome for manœuvring purposes Colonel Rimailho had provided an additional (travelling) carriage for it; by separating the gun from its firing carriage when travelling, it was possible to design the several component parts so that (*a*) the firing carriage, and (*b*) the gun on its travelling carriage each did not exceed in weight an ordinary field piece on its gun carriage.

The foregoing arrangement had its disadvantages; the space required in column of route was increased, loss of time occurred in bringing the gun into action, etc. The defects as well as the good points, of the Rimailho gun, were clearly summarized by Capt. Glück some months before the outbreak of the present War; an extract from Capt. Glück's summary relating to the defects and merits of the gun is published in the original article.

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The merits of the Rimailho gun were so great that it was thought capable of playing a universal *rôle* in the coming war and such a part had been assigned to it. The gun, as designed, was intended for direct fire and had in consequence a flat trajectory. However, Capt. M. A. Landrin devised a means for rendering the use of the gun possible for high-angle fire; a face-plate was fitted, by means of a collar and nut, on to the ogival head of the shell. The face-plate increased the resistance of the air on the nose of the shell during flight and brought about the desired curvature in the trajectory; this arrangement was only an expedient and possessed many drawbacks (*vide* discussion on the subject in Capt. Glück's *The French Artillery in Contest with German Heavy Artillery*). The question of introducing a howitzer into the French Army was under discussion in 1893, but as soon as the possibility of using the Rimailho gun for high-angle fire was demonstrated the Ministry dropped the idea of providing the French Army with a howitzer. The idea also seems to have prevailed that the "75" gun could be used as a howitzer should occasion require.

General Langlois had, in the course of his lectures (subsequently published under the title *L'artillerie en Liaison avec les Autres Armes*) at the *Ecole de Guerre*, laid down the essential characteristics required in a field piece intended for rapid fire some time before Colonel Deport designed his now famous gun.

General Percin was also to some extent responsible for the ideas that gave birth to the "75" gun; he had shown how it was possible to obtain the maximum utility from such a piece.

Thus, it came to pass that artillery experts became strong partisans in favour of the "75" gun, and at one time there was in consequence a serious division of opinion in high quarters of the French Army on the heavy artillery question. It is said that General Langlois led the attack in this campaign against heavy artillery; he seems to have been seconded by General Percin who, in his book *Le Combat* (published in the early part of 1914), condemned, for purposes of field warfare, guns having a range in excess of from 7 to 8 kilometres. Many details of this controversy, with extracts from the writings of those who took part therein, are given in the original article.

Public opinion in France seems to have been better informed on the artillery question than the French Government, which with the General Staff at its back, resisted the pressure exerted upon it for the purpose of bringing about an increase in the heavy artillery of the French Army; the Government seemed to consider 21 batteries of 155-mm. Rimailho guns (84 pieces) a sufficient heavy armament, although it was known that the Germans had 700 heavy guns. However, in April, 1914, a law was passed which provided for the increase of the heavy artillery of the French Army to 58 batteries (five regiments) 24 whereof were to be armed with the 155-mm. Rimailho (or T.R.) gun. Before this law could be fully put into operation the present War broke out.

When the Germans began their advance into Belgium, the French Army found itself practically without heavy artillery, whereas its adversary was well founded in this respect, and believed in that arm.

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During the progress of the War trench-mortars came into existence, and the experts who had been opponents of long-range artillery claimed to see in their introduction a confirmation of the correctness of their views on the artillery question. However, the inhabitants of the invaded regions who experienced a bombardment of their homes at ranges of tens of kilometres without the possibility of their defenders being able to reply thereto naturally did not appreciate the matter in the same light as these experts; they made their views known. Soldiers at the Front also began to urge the necessity of providing the French Army with heavy guns and a plentiful supply of ammunition therefor. It must be confessed that the experiences of the present War have upset all preconceived ideas regarding the *rôle* of modern artillery, the methods of its employment, etc.

Colonel Mayer recounts some of his personal experiences on the Flanders Front; from what he tells us, it is clear that the theory advanced by some experts, viz. :—that artillery fire can only be sufficiently destructive when directed against targets which are under direct observation, is no longer tenable. Long-range artillery fire against unseen targets has, in the present conflict, not only caused material destruction and loss of life representing very considerable cash values, but it has also often had a serious effect on the *morale* and discipline of the troops.

Camouflage Against Aircraft Observation.

The author of the original articles states that the Swiss troops have not, except in a few cases, had an opportunity so far of acting on any scale in conjunction with an Air Force. He points out that the execution of combined operations by land and air forces during peace-time is essential as a preparation for successful joint action by the two in war.

The view is also expressed that so long as the Swiss anti-aircraft defence troops cannot receive sufficient practical training, the only safe defence against the incursions of hostile raiders consists in suitable camouflage arrangements.

The various measures to be adopted to secure invisibility against aircraft observation are touched upon in the original article. It is pointed out that the main things to avoid are regularity and symmetry, in plan, of military works, of the disposition of guns in action, etc.

It is obvious, says the author of the original article, that the use of any existing forms of cover, such as barns, cart-sheds, stables are to be preferred to any artificial means that can be designed to hide guns, etc. The desirability of suspending all movements and of halting men, animals and vehicles in the shadows of walls, hedges, trees, etc. (where such exist), whenever hostile aircraft are heard or seen, is emphasized. Examples of cases of successful and unsuccessful camouflage are given by the author in the original article.

War and Surgery.

Paradoxical as it may seem, the War is proving a material benefactor to humanity, says the author of the original article.

A fourth congress of surgeons has recently taken place; it was preceded by the fourth reunion of ophthalmotogists. The results of the

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conferences in connection with these meetings have been to throw much light on important scientific laws and to point the way to practical applications of new knowledge likely to produce highly beneficial effects in the treatment of human ills.

Six questions of supreme importance were under discussion at the fourth session of the Inter-Allied Surgical Conference. On each of these questions definite conclusions were arrived at by all attending the Congress, owing, in a large measure, to the great amount of material available whereon to base such conclusions.

Details are given, in the original article, concerning some of the matters that came under discussion. Future generations will reap a rich reward from the work being carried on at these Inter-Allied Conferences.

The Value of the Oath.

The Lion of Lucerne is, the author of the original article points out, the symbol of the virtue which, during many centuries, has represented, the honour and the power of the Swiss; it is the emblem of fidelity to an oath. It commemorates those of the Swiss Guards who died on the 10th August, 1792; it was not for a mere idea or for their country that these men heroically met their end, but it was to preserve untarnished their word of honour, as the words "*fidèles à leur serment*" on the pedestal of the monument in question testifies.

For the foregoing reason, many Swiss, who still attach an importance to an oath, view with concern the spread of the opinion which is being insidiously disseminated that deserters and defaulters are persons worthy of respect, persons who are obeying but the dictates of their consciences.

Switzerland, just now, has a certain number of unpleasant visitors in the shape of deserters from the French and Belgian Armies and of German smugglers; they have been in continual conflict with the Swiss gendarmes. The severe measures adopted against these aliens has, it is stated, given rise to protests on the part of a section of the Swiss people, and, in consequence, the Swiss Federal Council has modified the measures introduced to deal with the pests in question. The policy of turning these folk out of the country has been reversed and the door is now opened wide inviting them to enter freely; in some cases young university students have even gone the length of crowning the renegades with garlands.

The author of the original article believes in calling a spade a spade. Deserters, he says, are really perjurers in every case, and in many cowards also. They may excite pity, he continues, but no person, who still attaches any importance to a man's word of honour, can by any sophism arrive at the conclusion that a deserter deserves to be treated as a hero.

Defaulters are even less interesting than deserters; they are men who have refused to obey the call of their native land in the hour of its need and distress. They have not the excuse to fall back upon that deserters have, *e.g.*, that they are suffering from shell-shock or from other horrors of a modern battlefield.

It is stated that the majority of the deserters who have crossed into Switzerland on being examined at the frontier have admitted that fear has been the force responsible for the abandonment by them of their colours. Once they get safely into the interior, however, all sorts of new

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excuses are invented by them ; they then become " conscientious objectors," disciples of a general disarmament, etc.

It is said that there are 40,000 deserters and defaulters in Switzerland to-day ; they are a source of anxiety to the authorities from every point of view. Some of them make a living by acting as spies and the majority of them are in active alliance with the Swiss anti-militarists.

Respect for Switzerland's dead and for her traditions imposes a duty on the Helvetic authorities to protect the Swiss youth and the Swiss Army against the contagion of the diseased minds that hold cowardice in a man to be an estimable quality and violation of an oath to be worthy of the loudest acclamation.

Divisional Training Centres.

An article was published in the number of the *Revue* for August last on the " Training Centre of the Swiss 1st Division " (*vide R.E. Journal* for October, 1918). Major F. Badoux in a contribution to the number of the *Revue* under notice states that the author of the original article in question has not done full justice to the work of the Swiss 1st Division, in the description thereof given by him ; he provides some further details of the instruction given at the Divisional Training Centre and expresses the opinion that the results obtained have been exceedingly satisfactory.

This number of the *Revue* concludes with a *Bulletin Bibliographique*. The following works, *inter alia*, are noticed :—*Les Allemands à Saint Dié*, by Raoul Allier (Payot et Cie, 1918. Fr. 4.50) ; *L'Armée de Verdun*, by Joseph Reinach (Eug. Pasquelle, 1918. Fr. 3.50) ; and *Brest-Litowsk*, by S. Grumbach (Payot et Cie, 1918. Fr. 2).

W. A. J. O'Meara.

Rivista di Artiglieria e Genio.

April—May, 1918.

German Apparatus for Production of Smoke.

Smoke production as a means of protection against an enemy's attacks, and also for concealing from the enemy one's own means of offensive and movements, has been constantly developed since the commencement of the War, and has found application by land and sea, and even in the air.

The Spanish Journal *Memorial de Infanteria* describes the smoke apparatus used by the German Army in war on land. There are three distinct types: Nebel-Topf (NL), Nebel-Kasten (NK) and Nebel-Trommel (NT). The Nebel-Topf for producing clouds of smoke (*Figs.* 1 and 2) consists of an iron-plated cylinder 0.91 m. in height and a diameter of 0.38 m. with two handles at half its height C, and a winch handle between, and closed by a cover A with lateral perforations. The axis of the hand winch is attached to a spherical iron receptacle B closed by a perforated tap C which can be made to turn at an angle of 180° by means of the hand winch. At the base of the cylinder is placed

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another receptacle in the form of a drum G, also made of iron plates, provided with a metal grate F and a cover E.

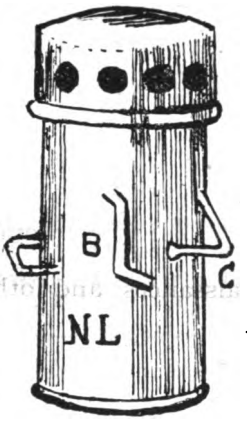

FIG. 1.

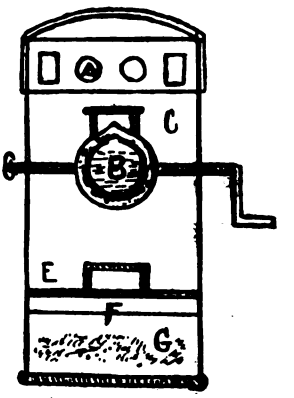

FIG. 2.

The spherical recipient contains a mixture of 12.2 litres of anidride and chloride of sulphur ; in the lower recipient there is placed 17.7 kg. of lime over which is the grate. The total weight of the apparatus when charged is 69 kg. At the moment of use they open the covers of the two recipients and by means of the hand winch, the spherical recipient is overturned with its mouth below ; the mixture then falls drop by drop on the slaking lime and the reaction develops much white and opaque smoke which issues from the circular perforation in the cover. The chloride of sulphur commonly called chloride sulphuric acid is a liquid which boils at 158° smokes in the air, and in water decomposes into sulphuric acid and chloric acid.

The apparatus of the Nebel-Kasten for producing clouds is similar in its working, but varies according to the forces of the machine, which consists of a cylindrical box D constructed of iron plates, and contains 10.9 kg. of lime in pieces, and of a cylinder A also made of plated iron supported by two metal rods fixed in the box and turned by a winch with a handle. The cylinder contains the mixture described above the quantity being 8.8 litres. The total weight of the apparatus when charged is 54 kg. ; its dimensions being 40 cm. in height and 35 in diameter.

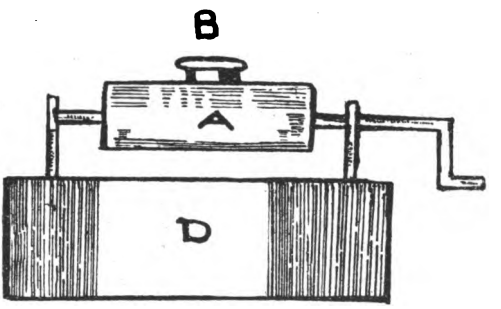

FIG. 3

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The third apparatus, Nebel-Trommel is of greater weight and volume being 0.71 m. in height with a diameter of 0.49 m. and weight 95 kg.; the principle of its working being the same as that described above.

These machines are placed in the parapets of the trenches and it is absolutely necessary to prevent them from coming into contact with water. The smoke issuing from them is not poisonous; and produces only a slight irritation of the throat and skin. The mixture described is not inflammable. The Germans use these smoke machines to conceal the arrival of reinforcements, changes of infantry and artillery, movements of troops in discovered places, and to guard against concentration of fire, to deceive the enemy by drawing his attention from places selected for attack, for covering the passage of dangerous places or rivers, and for concealing reconnaissances and other important attacks. Also, for concealing buildings, factories, etc. The distance between the machines and the place which they are desired to hide by means of smoke, varies with the direction of the wind; with a light wind it would be about 200 m.

The Journal relates that when some months ago, Marshal Hindenburg visited the Front in Flanders a large smoke screen was formed in front of the trenches in order to prevent the presence of the General Staff being observed from the enemy's positions. A similar apparatus is also used on board the Zeppelins when an attack by enemy's aeroplanes is foreseen, and its use is stated to be extended to Gotha aeroplanes.

Projectiles as Means of Communication.—In the history of the War examples are not wanting of hollow projectiles being used for sending notices to or from besieged cities. Among the more recent examples is that of their employment by the Japanese during the siege of Port Arthur, in sending a proclamation for the surrender of the besieged garrison. In the present War the Germans have extended their use regularly as a means of communication between the troops and the commands when other methods were wanting in the vicinity of the battles, especially when the telephone wires had been destroyed, and difficulties caused by the bombardments. The projectiles used for this purpose are given the name of *Nachrichtengeschosse* (projectiles for communication of notices) and are of various kinds and of different calibres. These are distinguished from the *Meldewurfgranaten* (shells for throwing notices) being of small calibre for use with bomb-throwers, and the *leichte Nachrichtenminen* (light mine shells for communication of notices used from light mortars).

The *Memorial de Infanteria* gives a summary description of the projectiles of the first kind. The *Meldewurfgranate* (*Fig.* 1*a*) consists of a metal cylinder A 37 cm. in length and of 3 cm. diameter. In the upper part B there is a metal case for the despatch. To this case there is attached a red Bengal light C which at its lower end has a grate for powder D. Below is a charge of powder E for throwing the Bengal light and the case out of the cylinder, and a flap F with compressed powder, and finally a charge H for the projection of the entire cylinder. The Bengal light burning at the height of the expulsion of the cylinder, which happens in the air at the time of the explosion of the charge E, continues to burn for a certain time and indicates the place where the case with the despatch will fall. The maximum range of 600 m. is

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obtained with an angle of elevation of about 32°. The *Leichte Nachrichtenmine* is constructed on the same principle, but of larger dimensions and obtains a maximum range of 1,300 m.

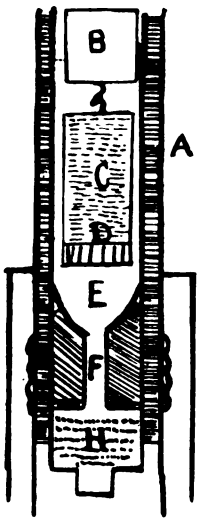

FIG. 1*a*.

June, 1918.

THE GERMAN LONG-RANGE GUN THAT BOMBARDED PARIS.

Since the 23rd March, 1918, the first day of the bombardment of Paris at intervals, from a distance of more than 115 km. the French journals have now been able to give a first summary idea of the materials used by the Germans and to obtain their object. Especially valuable are the articles that appeared on this subject in the *Genie Civil*, the *Illustration*, in *Nature* (H. Volta) and in the *Revue des deux Mondes* (C. Nordman). We have attached importance to these sources, excluding some of the first notices and deductions which in the light of later information appear to be less reliable. From the precedents of the present War we may notice an increased progression of gun range culminating in a bombardment from a distance at least triple to that obtained previously. As is known, one of the characteristics of artillery action since the commencement of the War which assured to the Germans important successes was the use of numerous mortars of large calibre with curved fire and a greatest range of from 12 to 14 km. For those conversant in military matters, this was no surprise as there were examples in previous campaigns, in the Boer War and the Russo-Japanese War. Especially in the last the Japanese in the battles of Mukden made use of several shells of Italian model up to 280 mm. The great development systematically made by the Germans in the employment of numerous batteries of 210, 240, 280, 305, and 420 mm., in the first months of the War caused surprise to the Entente. But after the experience of the first year of War a new tendency was shown; to the large calibres and curved fire used by the land batteries were added those of the guns of marine and coast batteries. Bombardments from the great distance of 30 km. were made from Compiègne and Dunkerque

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(1915), and from Nancy (1916) by pieces of 380 mm., and probably of 50 calibres in length. From this date, the employment on land of naval guns of large calibre became general in all the armies; all the reserve guns for ships of the line were taken from the arsenals, and several older ships were disarmed and their guns mounted on special carriages for use in the field. So, in all the great offensives of the past year the trenches were subject to furious bombardments from greater distances. For instance in March last the English Press reported bombardments by a certain number of German guns from a distance of 42 km. from the English lines. In addition to these artillery actions from long ranges the Germans attempted the bombardment of Paris by guns installed at a distance of about 120 km. (75 miles). This action was doubtless taken with a political view. It was announced thus by the Germans: "We will bombard the piazza-forte of Paris with a long-range cannon." The first shell fell on Paris on the 23rd March, at 7.30 a.m.; others followed at irregular intervals of about 20 minutes until 4.30 p.m. This continued almost daily to the 23rd April; from that date there was intermittent fire for a month to the 23rd May; the fire was then renewed with a certain regularity at each of the new German offensives. The heaviest loss was on Good Friday when a shell struck a church which was full of worshippers, causing the partial destruction of an arch. About 90 were killed and very many injured.

Suppositions and hypotheses that were made by the public and by the dilettante in improvised ballistics during the first days in France and elsewhere were false and useless. These fantastic notions contributed not a little to strengthen the enemy's game, surrounding this war-like creation of the Germans with an aureole of untruth. But at the end of the first days the French experts concluded that the artillery projectiles were projected with a very high velocity from a cannon of perhaps 100 or more calibres in length and that this would easily explain the exceptional range. We may now turn to the localities from whence the enemy's guns were fired, and to the projectile, given certain facts from which it is sought to deduce the data not yet known regarding the gun, the carriage, the charge of projection and the bursting charge.

L'Illustration thus describes the position of the guns:—"Photographs taken by aviators have shown precise indication of the positions of the guns that fired on Paris, which perfectly agree with the statements of prisoners. At first the Germans had in battery three of these pieces about 1,500 m. N.W. of Crézsy en Laonnois behind Mount Joie which is 190 m. in height with a profile in the form of a horse-shoe with the concave part towards Crézsy. The guns are installed in the interior of this concavity in a triangle with sides of about 800 m., on the margin of a forest. The guns were transported by a specially constructed road from a point on the Laon-La Fère railway distant about 8 km. from the Laon station, and were mounted on platforms fixed in cement, and well concealed by branches of trees. The enemy multiplied his precautions, to prevent the positions from being identified, placing around several anti-aerial batteries, and making clouds of smoke before the firing of the guns, and at the same time firing several pieces of large and small calibre so as to disturb the sound waves, and to render it more difficult to

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identify by the sound. From the commencement they abstained from firing at night so as not to reveal the position of the guns from the flashes. The position indicated above is about 115 km. from the centre of Paris. Not yet having been aware of these indications the French artillery commenced lively actions with guns of large calibre from counter batteries, and even succeeded in placing one of the pieces out of action; notices from neutral countries also stated that another of the pieces had burst during the firing and the third was stated to have been seen on its way to the arsenals for the necessary repairs. That would explain the interruption to the fire between the 23rd April and the 27th May."

Projectiles.—From examination of the fragments of the first artillery projectiles found in Paris (not aerial bombs) it appears that the thickness of the metal of the shells was from 3 to 7 cm. about.

Exact reconstruction of the projectiles is not easy owing to the fact that of so many shots fired not one failed to burst thus limiting the examination of the fragments. The comparatively small calibre first indicated was 240 mm., then 220 mm., and finally 210 mm. The more recent notices tend to the hypothesis of a calibre of 240 mm., and this would also agree better with the weight of the projectile, indicated as 250 kg. in the German notices available. As regards the metal of the projectiles, reference is especially made to its hardness; analysis reveals the presence of chromium and nickel in the proportion of 1 to 2 per cent. and of 7 per cent. of carbon. The shell is composed of two principal parts, a body of special steel indicated above about 50 c.m. in height and a cap of steel about 40 cm. screwed to the body. Given a calibre of 210 mm. the length in calibre would be 4.3 or reduced to 3.75 if the calibre is 240 mm. Some have an idea that the cap may have some arrangement for diminishing the friction of the projectile with the air thus facilitating its flight and assuring the greatest range. They refer to an invention made in France some time ago by a Russian, Chilowski, which was said to increase by 50 per cent. the range of any kind of projectile. They speak of a kind of bobbin with perforations through which during the course of the projectile through the air, warm gas is emitted, which would act in a certain degree as a lubricant and diminish the resistance of the air. Chilowski arrived at his invention through studying the system adopted especially in California to prevent the obstructions that were caused in the tubes for the transport of petrol from the pits and which consisted of placing water in the tube; this passing on the metal of the tubes formed a veil or curtain through which in its turn the petrol slided without friction from the metal. In the same manner Chilowski argued that the projectile would pass through an envelope of warm gas, and the friction with the air would in a great measure be eliminated. We have had no experience of this invention and there is nothing to show that it could be applied to the projectiles that fell in Paris. The sides have a thickness increasing from front to rear of from about 25 mm. to 40 mm. The internal cavity for the bursting charge is divided into two parts (the hind part being somewhat greater than the front) by a diaphragm. This diaphrgm is one of the particular points of discussion. It is believed that its unique function is to divide the internal cavity into two parts so as to prevent

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the bursting charge from exploding before the projectile leaves the gun.

More recently another hypothesis has been advanced, which would seem to be more logical, and that is in relation to the internal charge of the shell. It has been observed in the fragments of the shell not the smallest particles of explosive or of the products of combustion are found to adhere, and the hypothesis is that the shell is charged with one of the powerful explosives now generally used; that the smoke produced is white and has the odour of ether; and finally that all the shells without exception have burst on arrival. It is known that the smoke produced from the greater number of powerful nitrate explosives now generally in use is black owing to the carbon that is set free and the oxide of carbon that is produced in the act of combustion, and it is also known that this colour of the smoke renders observation more difficult. To obviate this defect the Germans added a certain quantity of nitrate of ammonia the smoke from which made observation easier. But the projectiles that fell on Paris produced, according to a great number of observations systematically made, a white smoke which does away for several reasons with the hypothesis of a return to an internal charge of black powder, an hypothesis also excluded by the absence of the characteristic odour of copper, and residue of combustion. For all these reasons, it is supposed that the Germans had adopted a method of internal charge, previously studied, which consisted of disposing separately in the projectile, two substances which mixing only during the passage through the air (lasting about 2.5 to 3 minutes) constituted a powerful explosive, certain to act on arrival of the shell, and a charge so to speak inert before the firing of the shot, with the greatest safety for transport and handling. They speak of an explosive of the type *panclastite* or *helloffite* which bursts with certainty on the arrival of the projectile with effects like those of nitroglycerine. For some time the German artillerists studied the action of *panclastite* for the internal charges of large torpedoes; the two substances were contained in two glass vases closed at the entrance. In the act of firing the glass was broken, and the resulting intimate assured the rotation of the projectile. This explosive requires a detonator of fulminate of mercury. *Helloffite* consists of nitrobenzine and nitrate acid; for the nitrobenzine, petrol or tar may be substituted. The diaphragm and its accessories serve to divide the cavity in the shell into two portions well separated, which are made to communicate only on the starting of the projectile. The little channels of communication in the diaphragm become opened and the heavier liquid from the front chamber passes into the back chamber while the projectile performs the ascending branch of its trajectory. By effect of rotation of the projectile the mixture would be well stirred up. For greater security, the back chamber is not filled until the last moment before introducing the projectile into the gun. The total volume of the internal chamber would not be greater than 6 litres, the quantity of explosive would then be from 10 to 11 kg. Among the fragments no fuses have been found intact, nor parts that would permit of their reconstruction; and this renders it more difficult to establish how the projectile functions on its arrival, with regard to the

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internal charge. The external portions of the projectile present peculiarities which are easier of explanation. Starting from the head the external superfices of the projectile can be divided into seven zones. The first (A) which is found immediately after the joining of the head and a little above and is smooth; the second (B) above and around the middle of the calibre and is furrowed with numerous small ridges from left to right, and according to the usual rifling of German cannon. Then follows (C) a zone consisting of a crown of red copper about 3 cm. with ridges like the preceding, and then another zone (D) of the height of half a calibre. The fifth zone (E) has ridges or rifling like the second but is somewhat higher. Then follows a second copper crown (F) somewhat higher than the first, and finally (G) the last short smooth zone.

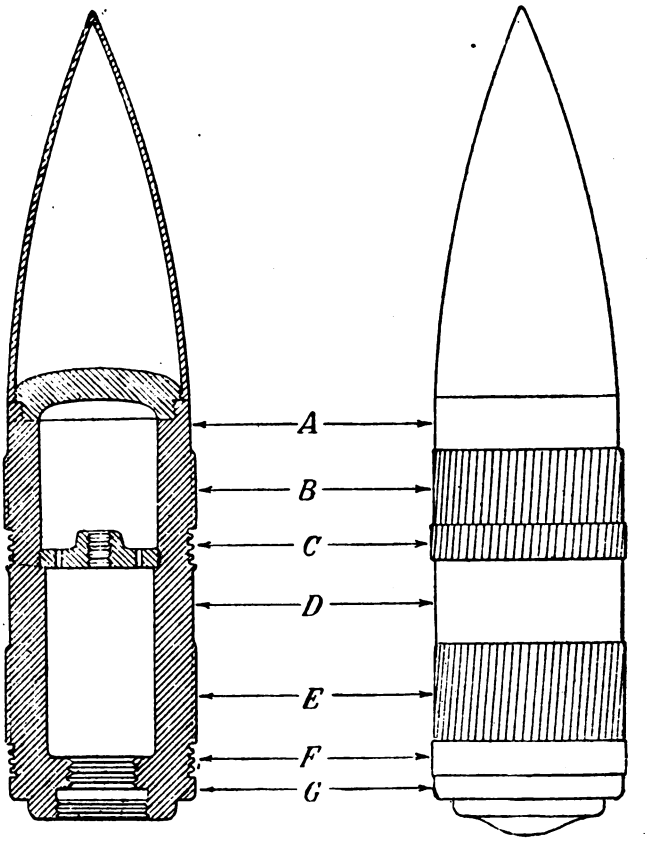

FIG. 1. FIG. 2.

The operation of loading these guns is very delicate and laborious and requires special mechanical calculations, it being necessary to screw the projectile into the barrel without causing damage to the rifling. Also the necessity of not consuming the material (which can only stand a limited number of shots) too rapidly explains the slowness of the firing. From certain indications in the fragments it is apparent that

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each gun's projectile is not interchangeable. According to the *Vossische Zeitung* the weight of the projectile, complete, would be 250 kg.

It is noted that the ordinary shells for naval guns (Krupp) of 210 mm. weigh only 125 kg. and those of guns of 240 mm. of the same type weigh 190 kg. It is not easy to explain the increase of weight given, that the weight of the projectile (250 kg.) is correct it is probable that the calibre would exceed that stated as 210 mm. As regards the calibre, this still remains uncertain, between 210 and 240 mm. and probably they have guns of different calibres. The Germans may not have constructed guns new in all their parts, but they may have utilized obsolete guns of 381 mm. re-tubing them to reduced calibres of 210, 220, or 240 mm.

The most powerful of the Krupp guns have a length of about 20 m.; the length of the bore is about 19 m.; re-tubing this piece to a calibre of 210 mm., the length of the bore would be 90 calibres exactly. The powder chamber for a gun of 381 mm. can contain up to 315 kg. of powder, which is much above the charge of the gun that fired on Paris. There is then no necessity for new studies and calculations as to the resistance of material. These would be reduced to the simple operation of re-tubing guns deteriorated by use. It is true that a newly-constructed gun of 210 mm. may be somewhat lighter than a gun of 381 mm. re-tubed to a calibre of 210 m. whose weight would amount to 100 tons, but it has to be taken into consideration that a gun of such length, with less thickness of metal, would be subject to a more or less pronounced curvature according to its inclination, and the exceptional vibrations in the act of firing which would influence very seriously the precision and regularity of the fire. Instead of this, in a gun of 381 mm. re-tubed to 210, 220, or 240 mm. the exceptional strength of the sides of the bore would cause the vibrations to be less than those in a gun of 381 mm. of 50 calibres. It may be added that this solution would admit of the Germans utilizing the carriages of the type of the guns of 381 mm. employed in the bombardments of Compiègne, Dunkerque, and Nancy, without new studies and calculations as the fire against those places doubtless required the greatest elevation up to 45° if not higher.

The Problem of the Fire with Range of 120 km.—It is necessary especially to bear in mind the character of this very special fire, and the conditions under which it was conducted. The Germans at the commencement of the current year had a target at about a distance of 110 km. from their first lines which had repeatedly been made an object of bombardment from Zeppelins and aeroplanes, which threw bombs up to a weight of 300 kg. with enormous bursting charges of about 180 kg. of powerful explosive, and it is well known that whatever may be the active aerial and anti-aerial defence of a city, it is not possible to prevent some airships from discharging their bombs. So that there was not wanting to the Germans the hope of intimidating the population of the capital. They also had another effective means represented by a projectile of certainly a much less weight than the great aerial bombs. There was also the advantage of being able to fire when the atmospheric conditions did not admit of aerial flights. The problem presented itself in these terms: To hit a target of a superficies of 7,800 hectaires from a distance of

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about 115 km. (72 miles) of an approximately circular form with a diameter of about 10 km. the increase to the range and the increase to the calibre would evidently proceed step by step; the problem was imposed on the Germans in new terms, as was rightly observed by Fioravanzo in the *Rivista Marittima*—and tended to surprise the experts, especially those of the marine, who were accustomed to consider the problem of the increase of range and the power of the guns only in relation to an increase of calibre and very few in relation to the increase of initial velocity nor to the angle of projection, given the special character of the fire of ships against armoured targets. This logical view of determining the scope of greatest effect against a resisting target does not apply in the case of a fire of intimidation against a vast horizontal area, and the study of construction becomes concentrated on the points; greatest increase of the initial velocity and the angle of projection. Increase of the angle of projection, and initial velocity are the obvious conditions for obtaining an increase of range in any kind of gun or mortar. But now, in the case of the guns under examination these elements were increased beyond any previously known limits, and the greatest possible advantage presented by obtaining the least possible resistance of the air to the projectile during its passage through the air, which is found to be much rarefied at a great height. As has been stated in several journals, General Rohne at first wrote in the *Vossische Zeitung* that the guns in question fired with an angular elevation of over 45° and precisely 55° contrary to the universally admitted principle that the greatest range was obtainable with an angle of projection somewhat less than 45°. The reason of this innovation being as follows:—The density of the air increases very rapidly with the increase of height; a litre of air at the normal pressure of 760 mm. and a temperature of 15° weighs 1,293 g. at the level of the sea; at 5,600 metres in height the weight is reduced one-half, at 8,000 one-third, and at 1,000 m. one-quarter; and it may be supposed that at a height of 20,000 metres it would not weigh more than one-tenth. Other data are the following:—

Density of the air at 5,000 m. $\Delta = 0.54$.
,, ,, 15,000 m. $\Delta = 0.15$.
,, ,, 30,000 m. $\Delta = 0.023$.

It may be remembered that the greatest height gained by man (ascent of Preussen in 1901) was only 10,698 m. The greater heat conferred on the projectile owing to its high velocity contributes to diminish the friction since the air in contact with it is dilated and rarefied.

Finally, in the case of attaining very long ranges with curved fire and a very high co-ordinate, this also agrees to a certain extent with the diminished value of the acceleration of gravity at great heights, and this is always diminishing as the projectile ascends. It is calculated that to attain ranges in a vacuum of 110, 120, and 130 km. with an angle of projection of 45° would require initial velocities of 1,100, 1,200, and 1,300 m., respectively, and that to compensate for the diminution of the range caused by the resistance of the air, even under the favourable conditions of the German artillery with the newest guns, it would be necessary to increase that velocity by 20 per cent. According to

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theoretic calculations for a range of 120 km. we should approach to an initial velocity of 1,460 m. as indicated by General Roche. As regards the falling velocity, it is certain according to known data, that it exceeds that of sound. At Paris, the sound produced by the displacement of the air caused by the projectile was not perceived until after the arrival of the projectile. It is calculated that the falling velocity may exceed 500 m. and perhaps be as much as 700 m. The element which most influences the increase of the range is the diminished density of the air at the great height attained by the trajectory.

Certain notable communications by the celebrated mathematician de Sparre of the Academy of Science at Paris in 1915-16 are well worthy of consideration. The calculations for a trajectory of a projectile of 381 mm., with a weight of 760 kg., projected with an initial velocity of 940 m., and with an angle of elevation of 45°, gave the greatest range as from 25,692 m. or 35,359 m. supposing the density of the air to be constant and equal to I, where it's taken into account the effects caused by the diminution in the density of the air in the different strata of the trajectory. In the second hypothesis there is an increase of range of 38 per cent. as compared with the first. And it may be noted that the greatest co-ordinate gained by the trajectory of a projectile of 381 mm., as considered by de Sparre is 11,382 m., not even a third of that calculated for the guns that bombarded Paris. De Sparre calculates the influence on the range of guns of 381 mm., caused by the temperature and normal pressure, which are considered in the tables of fire, respectively of 15 C. and 750 mm., and obtains by result that an increase of temperature of 13 C. and a diminution of pressure of 10 mm. would produce an increase of range of 1,792 m.; *vice versa* a diminution of temperature of 13 C. and an increase of pressure of 10 mm. would cause a diminution of range of 1,276 m.

We may say, that since the passage of Halley's comet no scientific phenomenon has caused so much interest and so much discussion, and it is certain that this last creation of the Krupp factory of cannon throwing 120 km., deserves to be followed with the greatest attention, as it is probable that it may be in its initial stage of practical employment, and much is still unknown with regard to the characteristics of new material, after several months, and the only objects of direct examination have been the fragments of the projectiles.

The writer of this Notice happened to be in Paris on the 28th and 29th May, when several shots were fired from the long-range gun. The people who were taking their tickets at the St. Lazare railway station took no notice at the time of the firing, and " carried on " as if nothing particular was happening.

E. T. THACKERAY.

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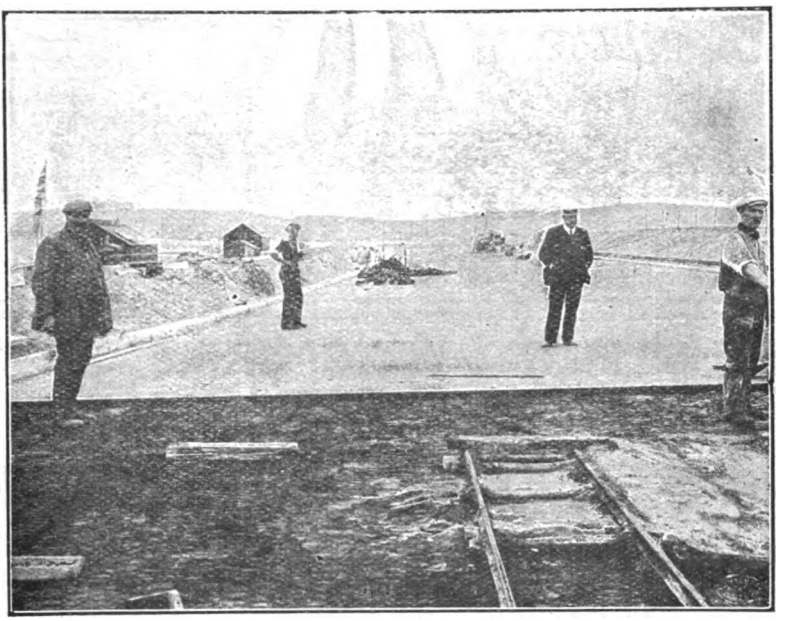

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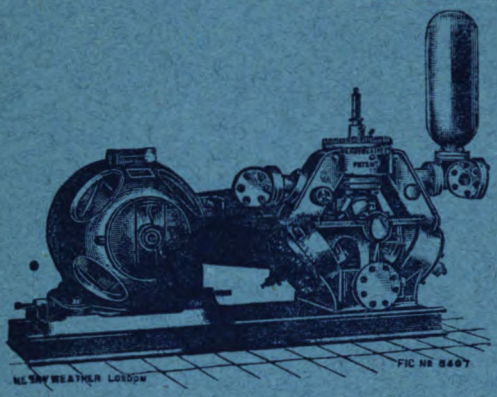

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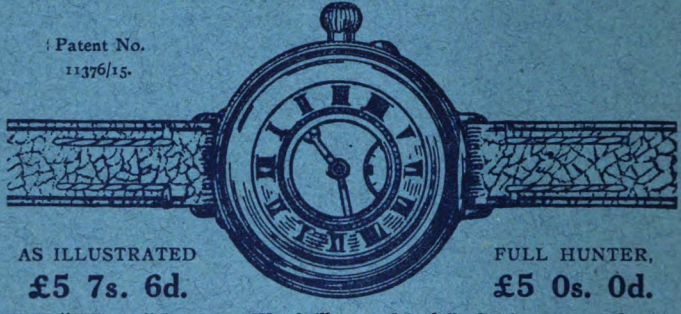

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5. NOTICE OF MAGAZINE :—

   Revue Militaire Suisse. By Lt.-Col. W. A. J. O'Meara, C.M.G., *p.s.c.*, late R.E. (Barrister-at-Law of the Inner Temple) 250

Authors alone are responsible for the statements made and the opinions expressed in their papers.—(G. 5281).

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LAUNCHING AN INGLIS BRIDGE.

By CAPT. A. TAYLOR, R.E.

THE following notes on launching a heavy triangular type Inglis Bridge on wire cables over a gap of 216 ft. without the aid of a carriage have been forwarded by a Chief Engineer.

Site.—The bridge had to span a river whose banks rose steeply to a height of 140 ft. above the water level on the north side, and 85 ft. on the south side.

Anchorage for Cables.—Four ¾-in. diam. cables were employed in pairs to support the bridge during launching and were anchored. On the south side two 12-in. × 12-in. timber baulks sunk into the ground behind a large boulder and on the north side four oak trees were utilized. The cables were made fast 13 ft. apart to the 12-in. × 12-in. baulks and the loose ends taken across the gap by means of an aerial ropeway previously erected. They were then passed round the rear two trees and hooked on to 3-ton differential tackles. The strain being taken on the cables, with the differential fastened on to the *near* trees. All seizings were by means of wrought-iron clamps. The distance between anchorages on north and south banks was 545 ft.

Bridge Seatings.—A plumb line dropped from the cables gave the exact line for the bridge seatings. These were raised to the required level on crib piers, M.S. cubes being employed.

Winches.—For hauling the bridge across the gap two 3-ton winches were placed in line between the cables on the north side and bedded down. One 3-ton winch was sited on the south bank to control the bridge from the rear.

Erecting and Launching.—As the Inglis Bridge was to be launched from the south side, a distance of 30 ft. from the front of the crib piers to the bank was required, which formed the shore bay and erecting platform. This was decked over with 9-in. × 4-in. and R.S.Js. Two bays of bridge were then erected. A false transom had meanwhile been made and fitted with a guide shoe at each end, so that the cables would clear the superstructure of the bridge. This transom was now secured under road transom No. 2, and the cables inserted under the guide shoes. By hauling on the differential tackles all slack was taken up on the cables. Two 1-in. diam. wire cables were made fast to No. 1 transom and passed through the

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winches on the north bank, and 1½-in. diam. cable secured to No. 1 pyramid and passed back to the winch on the south bank. Side and back guys were also used to control the launching.

The bridge was then launched forward one bay. By adding a bay and launching a bay at a time the whole span was taken across the gap. One bay was always kept in hand on the launching platform.

After the fifth bay had been added it became necessary to lessen the dip of the bridge. This was done by pulling up on the differential tackles, and also using men and R.S.Js. as a counter-balance on the bay on the launching platform. When No. 1 transom of bridge reached the north abutment the bridge had a slope of 1·5°.

As it was impossible to raise the bridge on to its seating with the differential tackles, owing to the heavy strain on them, the top cubes of the crib piers were dismantled. The bridge was then jacked up and the crib piers reconstructed. After the bridge was properly seated, the cables that the bridge was launched on were slacked away, and placed under the false transom which had been inserted at the centre of bridge. This was No. 10 transom. The cables thus formed tension ties for the support of the bridge at the centre of the span, and after hauling up as tautly as possible with the differential tackle, they were made fast at the anchorage.

In carrying out the work above mentioned the following points were noted :—

(*a*). The two ¾-in. cables did not give a sufficient margin of safety. 1—1⅞-in. diam. cables on either side of bridge are necessary.

(*b*). 3-ton differential tackles are insufficient for adjusting the cables. Two 6-ton tackles are required, or larger.

Remarks.—As the Inglis Bridge is capable of supporting its own structural load over a span of 200 ft. or more (without channel for roadway) it is possible by increasing the number and strength of the tension ties to render such a bridge suitable for the following traffic :—

Infantry in file.
Field guns.
First line transport.

For the launching and erection of the bridge, the man-hours worked were 4,000 employing a party of 50 men. One hundred and fifty men working in three shifts of eight hours should put in anchorage, erect crib piers, and launch and complete bridge in four days.

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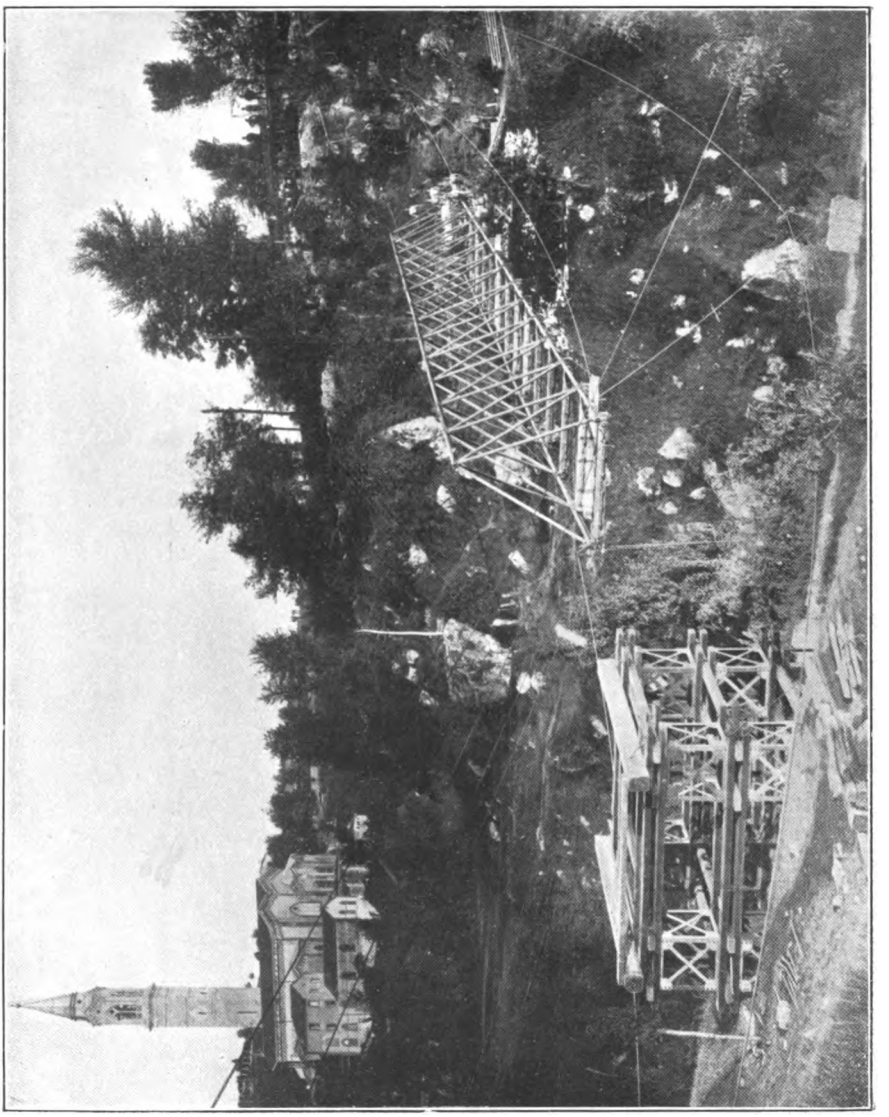
LAUNCHING AN INGLIS BRIDGE.



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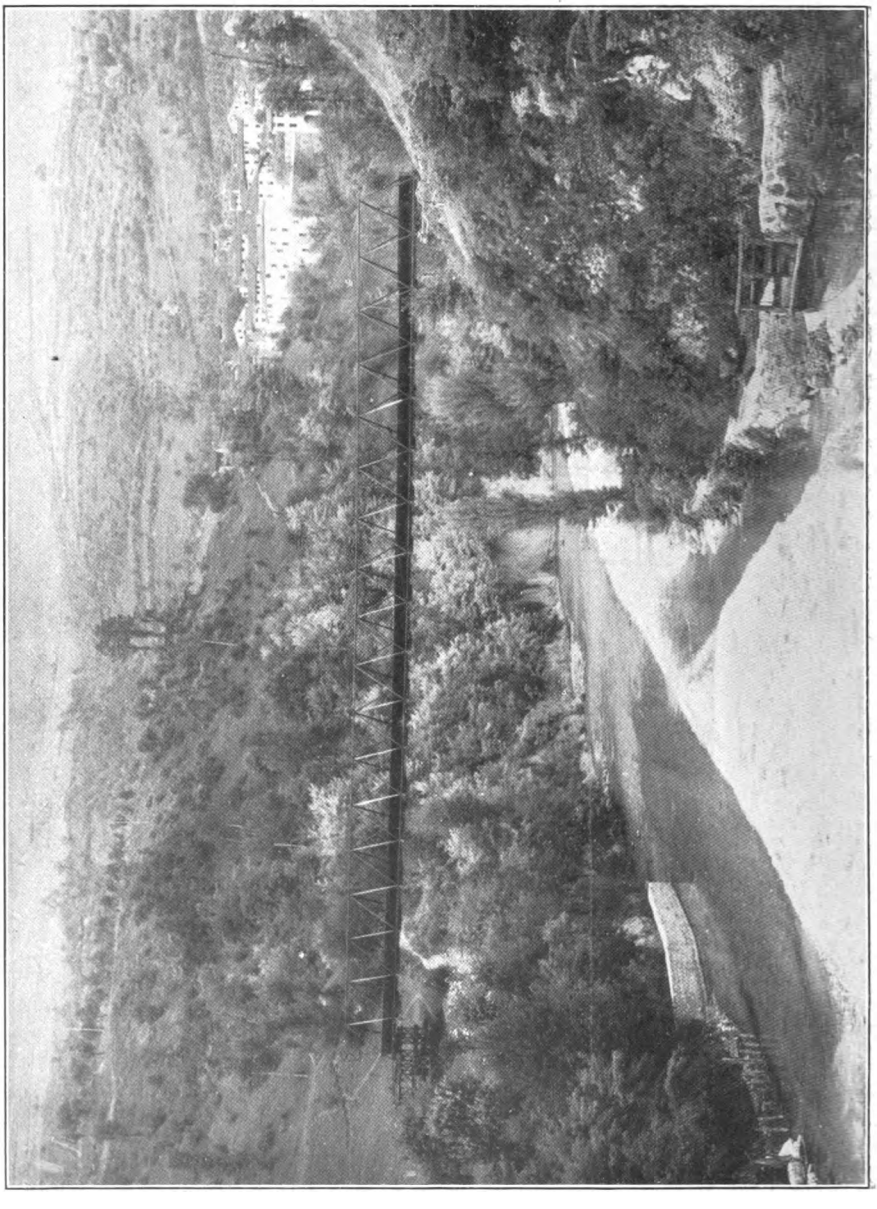

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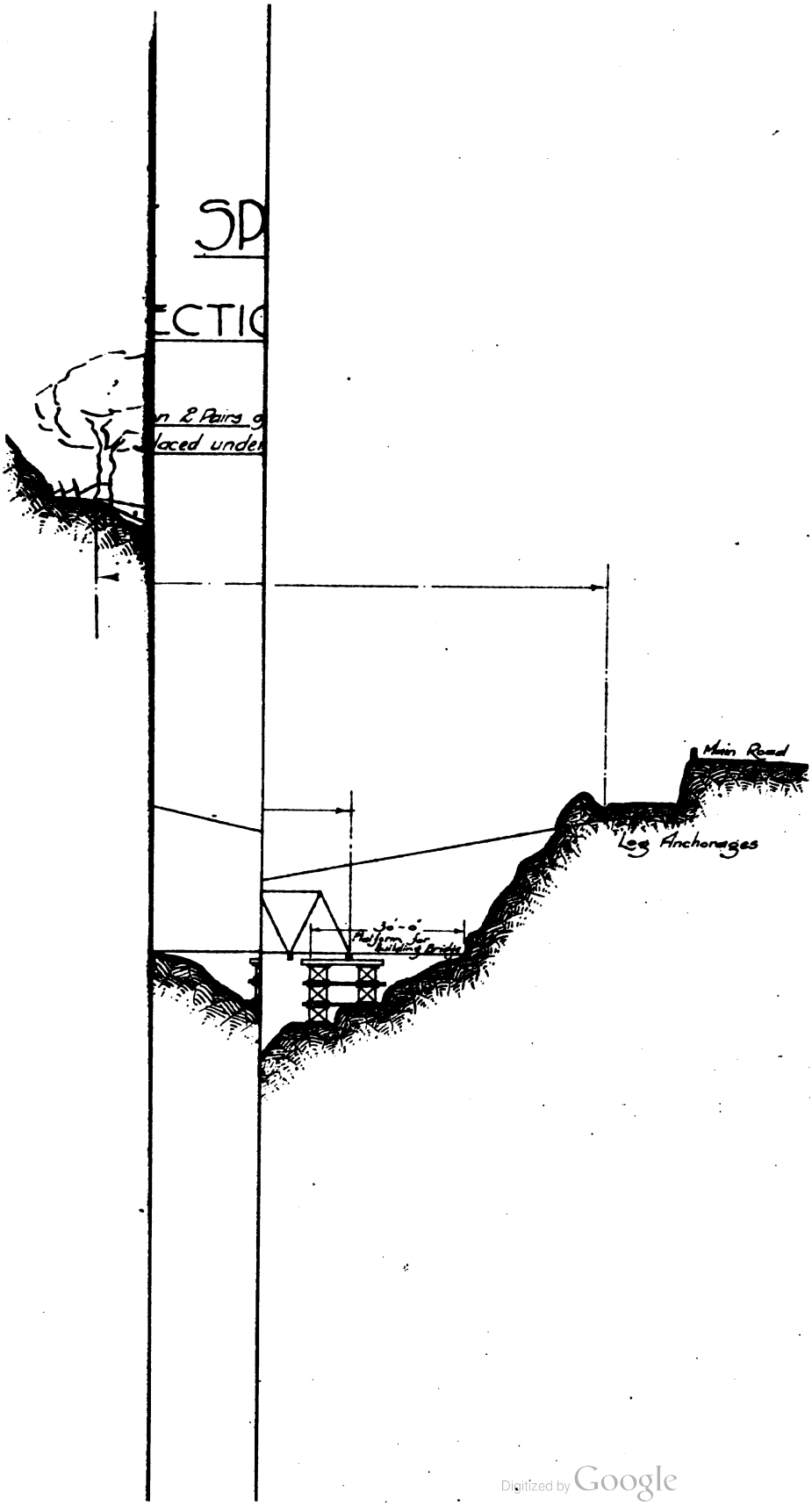

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WATER SUPPLIES TO A MOUNTAIN PLATEAU.

By CAPT. H. B. WARD, M.C., R.E., M.SC., M.ENG., A.M.I.C.E., P.A.S.I.

Topography and Geology of the Plateau.—The plateau under consideration lies at an elevation of 3,000 ft. above sea level, bounded on the north by steeply inclined hills rising to an elevation of 5,000 to 6,000 ft., and on the south by more gently sloping ones averaging some 4,000 ft. above the sea.

To the west and east, the plateau descends abruptly to the Valleys of the " A " and " B " respectively. Broadly speaking the Northern and Southern mountain boundaries are composed of a calcareous limestone of the lower Jurassic formation. This rock is light coloured, generally pale grey or yellow, and moderately hard. The important characteristic of this limestone is its extraordinary permeability, with a resulting absence of natural springs.

The basin forming the actual plateau is composed almost entirely of another variety of calcareous limestone belonging to the lower Cretaceous system. It is mostly concealed through a light covering of soil, and is very permeable. Both limestones are extensively fissured ; fissures are known that are over 800 ft. deep by 20 ft. in breadth, and there are a great number of smaller ones.

As a direct result of its geological formation, the plateau is noted for an almost entire absence of springs ; all the rain and melted snow is rapidly lost through the numerous fissures and hence special arrangements have to be made for the supply of water. There are a few small springs, whose existence however is of no assistance to the British Forces, since they are in enemy hands.

Sources of Supply.—Down on the plains on the foot of the mountains forming the Southern boundary of the plateau, several good springs emerge, and these appear to owe their origin to the percolation of rainwater and melted snow through the very permeable formations referred to. These springs vary throughout the year corresponding with the rainfall, but their variation is gradual with the changes of the seasons, and the larger ones are not liable to the rapid fluctuations that occur in mere surface springs. Owing to the highly fissured nature of the limestone, slight impurities gain access to the spring waters, and generally half a measure of chloride of lime is needed per 110 gallons to sterilize the water.

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Delivery to the Plateau.—The question of supplying the plateau with water resolves itself then into a purely engineering problem, pumping plant being established at each of these main springs on the plains to lift water to the summits of the mountains, from where service reservoirs feed by gravity the Plateau Area.

Several pumping schemes were already in operation before the British Forces were in the line on the plateau, but as a portion of the area occupied was not sufficiently supplied, new work was commenced. The spring selected was one which delivered about 40,000 gallons an hour, the work being carried out by the Ufficio Idrico of the Italian Army concerned as far as delivering water to the mountain summit. Forward of this, British Army Troops Companies, R.E., assisted by Field Companies, laid the gravity main and constructed the water-points. Initial and relay pumping stations were erected, as it was desired to obtain as large a delivery as possible. Had the total lift been done by only one pumping plant, not more than half the quantity of water would have been delivered. The total lift was approximately 4,200 ft., divided into two lifts of 2,100 ft. each.

The plant at each pumping station consisted of a pair of reciprocating 3-throw ram pumps, specially designed for high-lift work; two were made at Milan and two at Turin. One pump at each of these stations had a duty of 1,600 gallons an hour and the other a duty of 2,400 gallons, so that when both worked simultaneously a total quantity of approximately 4,000 gallons per hour is delivered 4,200 ft. above the source of the spring. The pumps were designed to work against a head of 2,300 ft. in this case. The motive power at each pumping station consisted of four high-speed petrol motors, each about 45 h.p. Two motors were sufficient to drive both the pumps, and the other pair were in reserve.

As in all high-lift pumping schemes the piping required special attention, the usual 4-in. screw jointed pipes being quite inadequate. Instead steel tubing, 2½ in. diameter, by Messrs. M. was used, the joints formed of two heavy flanges brought together with bolts, which tightened on to a rubber ring circular in section held in a soft metal casing. These pipes stand a pressure of 4,500 ft. of water, and pumps are made by both the firms already mentioned to lift against a maximum head of 4,500 ft. Thus the piping and pumps available corresponded as to their ability to stand these maximum pressures, and installations are in existence where water is lifted 4,500 ft., at the rate of 800 gallons an hour.

Where greater deliveries are required, the lift is divided into two portions, and pumps are then available to deliver 2,400 gallons an hour against heads of about 2,500 ft. In the pumping plant established the rising main was 5,000 yards long, 4,000 yards being of steel tubing, the upper 500 yards on each section of the rising main being made

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with the usual 4-in. screw jointed pipes. Work was commenced in the middle of March, and by the 25th of April, water was delivered to one of the important roads on the mountain slope, 3,500 ft. above the spring, and 10 days later water was pumped to the summit of the mountain, 4,200 ft. above the source. This particular mountain summit is 4,900 ft. above sea level.

The lower pumping station was close to a main road, and the transport of plant and materials was therefore simple. The only other road crossing the pipe-line was the one referred to, 3,500 ft. higher up, and much of the piping for the upper section of the rising main was delivered by lorry on this road, and carried down the steep mountain side by hand. The gradient of the piping averaged 1 in 3 from the spring to the summit.

Engines and pumps for the upper pumping station were pulled up rough mule tracks from the main road at the mountain foot by large parties of Italian civilian labour ; one of the motors being drawn up by a party of 60 Italian girls ; pumps being hauled up by parties 40 strong, and so on.

The rising main was laid on the surface of the mountain side to save time, and subsequently dropped into a trench about 2 ft. deep. Most of this trench had to be cut out of rock. Selection of a site for storage reservoirs on the summit was made with a view of their being out of direct vision from the mountains held by the enemy. Four 9,000 gallon tanks were erected, with timber floors and sides, lined with the usual tarred tarpaulins 30 ft. square.

Delivery by Gravity Forward of the Summit Reservoirs.—The first 2,000 yards forward from the summit reservoirs traversed rather difficult country for pipe laying. Broadly speaking the line of least resistance was followed, the pipe-line descending slowly at first below the summit, and then dipping steeply downwards to a valley leading towards the first water-point. The ground was reconnoitred when there was 3 ft. of snow on the upper slopes of the mountains, most of which had, however, melted by the time work was commenced.

Four-in. screw-jointed piping was laid on the surface, except where deep ravines and considerable irregularities were met with, when timber trestles were erected and the pipes supported on them. With a view to the avoidance of trouble in the winter, the whole main was laid with a continuous gradient forwards, so that it can be emptied as soon as a water-point has been filled without leaving any water to freeze in the pipes. The upper end of the main was left open just above the first intake from the reservoirs, to allow air to escape, and several air valves were put in at rapid changes in the gradient. Four expansion valves were also put in, in a length of 2,000 yards, to relieve strains at the joints due to the wide diurnal range of temperature. As soon as the pipes were covered, these valves practically went out of commission. At 2,000 yards from the reservoirs an im-

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portant road was met, where the first water-point was established at a level of 750 ft. below the summit. The usual 30 ft. square tarred tarpaulin-lined tank was used throughout, raised sufficiently on short round timber piles to enable the floor to clear the irregularities of the ground.

All tanks supplying water-points were placed 20 to 30 ft. above road level, this greatly facilitating rapid re-filling of water-carts, an arrangement made easily possible by the fact that on one side of almost all the mountain roads the hillside rose steeply from the road level. Immediately below this first water-point, an automatic pressure reducing tank was installed. This tank was half-way as regards level between the mountain summit and the level of the plateau, and was a 400-gallon galvanized iron tank fitted with two 2-in. ball valves. The main from the mountain on reaching the tank divided into two branches, to each of which 4-in. to 2-in. reducers and 2-in. ball valves were fitted.

The piping was admittedly subjected to pressure in excess of what would be considered advisable, the lower end of each section of the gravity main sustaining a head of about 750 ft. Very few leaks or breaks occurred however, and the breaks were nearly all longitudinal splits, some pipes being found to be weak along a seam-line from end to end.

Some difficulty was found at first with the washers in the ball valves not being suitable for a high pressure ; this was overcome, as also a tendency to bend in the arms between the balls and the valves. From this pressure reducing tank a 4-in. main continues through the forest to the front line, supplying several water-points en route. At two points branch mains of 2-in. piping, about 2,000 yards long, were taken off it ; the 2-in. pipes being large enough considering that each of the subsidiary pipe-lines left the main where the head of water was fairly considerable. The ease and rapidity with which 2-in. mains can be laid in mountainous country as compared to 4-in., is to be noted, and the use of the smaller pipes is often possible when the head available is as great as it usually is in the mountains.

Horse-Watering.—The difficult problem of horse-watering on the plateau was greatly relieved by the existence of several large ponds possessed of clay bottoms, which were available until late in August. All ponds were fenced round with barbed wire, and animals prevented from walking into them. Lift and force pumps and troughs were fitted up, and it was not until late in August, and in some cases early in September, that piped supplies had to be drawn on to any extent.

To guard against any temporary shortage of horse-water, and to provide a reserve which would be required in the event of operations (since with a greatly increased number of horses and mules on the plateau the pumping plant could not then have coped adequately

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with the demand) four horse-water storage points were established. These each contained 25,000 gallons and were kept full, being supplied from the piped systems. 100,000 gallons were thus kept in reserve. In addition to horse-water supplies from ponds, and from the mains, a good deal of very useful work was done by Divisions in the construction of tarpaulin-lined catchment pits. These were dug into the ground in carefully selected positions, to which surface water would run during heavy rain. Pumps and troughs were fitted up, and at the best of these pits a few hours' heavy rain was sufficient to accumulate 9,000 gallons of water for horse supplies.

Winter Precautions.—Precautions against frost have to be undertaken most thoroughly on the Plateau. The mean annual temperature for "A"——is only 7° Centigrade, the coldest month being March, whose mean temperature is 0·8° C. From November to April inclusive an almost continuous frost exists, with the thermometer at or below zero for 25 days or so per month. Generally on the Plateau it snows from November to the end of March, the mean annual depth of snow being 4 ft. With these conditions for six months of the year, the usual comparatively shallow burying of mains is of little or no protection, and to reach a safe depth the trenches would have to be cut out of solid rock, at the expense of an immense amount of time and labour. Pipe lines are generally covered over with 18 ins. to 2 ft. of earth, and the special precautions detailed below taken in addition.

(*a*) *Rising Mains up to the Mountains.*—Placed at the bottom of the rising main close to the pump is a washout valve, and this is opened at night once the cold weather sets in, the main being emptied. In certain cases the rising mains are not entirely emptied, but sufficiently so as to ensure the water being in motion during the night.

(*b*) *Gravity Mains.*—As already stated, these are graded so as to admit of them being emptied except when water is actually passing down the main to re-fill a water-point. Water should not be allowed to stand in mains at night (unless deeply buried) or in the daytime either during the more severe frosts. Where hollows in the line of the main are unavoidable, washout valves are put in, so that the whole main can be emptied.

(*c*) *Water-Points.*—Since the timber tarpaulin-lined tank is quite unsuitable in the winter, special ones have been prepared. These are built in masonry and concrete, and are rectangular in form with a 6-ft. depth of water in them. Excavations in every case had to be cleared by blasting, and when the sites were prepared, walls varying in thickness from 2 ft. to 3 ft. were put in on a 12-in. floor of concrete. The roofing was supported by rolled steel joists carrying a 6-in. layer of concrete with reinforcement of expanded metal. The roof was covered over with a 2-ft. layer of stones and earth and dry walling 2 ft. thick built up around the exposed portions of the walls.

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The draw-off pipes from these winter tanks were fitted with the control valves placed immediately outside the masonry walls, so that as soon as a water-cart was filled and the valve closed, the delivery pipe emptied itself at once. Since the tanks were placed well above the roadway, the draw-off pipe had a continuous gradient to the water-cart or lorry being filled. The valves are worked by the Water Police at each water-point. The short length of piping to the dixie-filler was the only pipe filled with water during the daytime, and was buried deeply. The actual dixie-filler consisted of a length of 2-in. piping, with half a dozen 1-in. branches from it, to which latter were fitted ¾-in. bib-cocks. The 2-in. pipe was laid to a gradient, the lower end being plugged off, and the 1-in. branches were inclined backwards to the 2-in. main, so that on removing at night the plug referred to all water was withdrawn from the piping at the dixie-filler. The whole was built into a solid mass of masonry and concrete.

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RELATION OF WEIGHT OF RAIL TO AXLE-LOAD.

By G. RICHARDS, M.INST.C.E., Chief Engineer with the Railway Board, Simla.

THE following, which is Technical Paper No. 188, has been kindly provided by the Chief Engineer with the Railway Board of India :—

During the last few months several Engineers have asked—

(*a*). Why the Railway Board have laid down different scales of axle-loads for the 5 ft. 6 in. gauge and for narrower gauges ?

(*b*). To what extent the axle-load for any weight of rail may be increased with closer spacing of sleepers ?

The scales of axle-loads are given in the " Schedules of Maximum, Minimum and Recommended Dimensions to be observed on all {5 ft. 6 in. / 2 ft. 6 in. / metre} gauge railways in India " which were distributed with the Railway Board's Circulars {No. 1820 R.C., dated 2nd July, 1913. / No. 1262 R.C., dated 8th May, 1913. / No. 1831 R.C., dated 3rd July, 1913.}

5 *ft.* 6 *in. Gauge.*—Item I (15) of the Schedule reads as follows :—

Minimum weight of rail per yard for each ton of weight on a pair of wheels :—

Axle-load, *i.e.*, weight on a pair of wheels including weight of wheels and axles.	Minimum weight of rail per yard.
12 tons 0 cwt.	60 lbs.
13 ,, 10 ,, ...	65 ,,
15 ,, 2 ,, ...	70 ,,
17 ,, 0 ,, ...	75 ,,
18 ,, 12 ,, ...	80 ,,
20 ,, 8 ,, ...	85 ,,
22 ,, 12 ,, ...	90 ,,
24 ,, 14 ,, ...	95 ,,
26 ,, 18 ,, ...	100 ,,

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Metre Gauge.—Item I (15) and *2 ft. 6 in. Gauge* Item I (18) read as follows :—

> Minimum weight of rail per yard for each ton of weight on a pair of wheels, 5 lbs.

Below these items in all three of the schedules, is the following note :—

> With closer spacing of sleepers a less weight of rail is permissible.

We know very little about the actual stresses in rails in an elastic road under a train, so opinions must differ about the relation of weight of rail to axle-load.

The following note, which I compiled a few months ago from the Railway Board's records, shows (*a*) reasons for the scales of axle-loads which are prescribed in the Schedules of 1913 and (*b*) the limitations of closer spacing of sleepers.

(*a*). *Scales of Axle-loads.*

1. The maximum axle-loads prescribed in 1913 were fixed after careful consideration of the remarks of the principal Railway Administrations which were received in response to Railway Board's Circular No. 2915 R.C., dated 2nd November, 1911. Only two railways objected to the scales of axle-loads circulated with that letter, viz., the Bombay, Baroda and Central India Railway whose Chief Engineer suggested that the *weights of rails* were decidedly too small and the South Indian railway whose Board of Directors appeared to prefer the old uniform scale of 5 lbs. weight of rail per ton of axle-load and whose Consulting Engineer wrote : " I have been unable to find out that the proposed altered weights are calculated according to any of the formulæ on the subject with which I am acquainted."

2. The old uniform scale of 5 lbs. weight of rail per ton of axle-load unduly restricted the axle-loads that could be carried on rails weighing over 60 lbs. per yard : for instance, only 15-ton axle-loads were allowed under the old scale to run on 75 lb. rails though it was known that 17-ton axle-loads could and did do so.

3. Long experience had shown that a 60 lb. rail is quite suitable for 12-ton axle-loads with the ordinary number of sleepers (say about 1,900 or 2,000) per mile.

4. The following table was prepared in the Railway Board's Office in 1911 to indicate the axle-loads which are probably suitable for various weights of rails on the assumption that 12 tons is the correct axle-load for a 60 lb. rail with regard to both stiffness and strength of the rail :—

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Weight of rail in lbs. per yard. (w)	Old Government Rule. $W=\frac{w}{5}$.	Axle-load in tons (W). According to stiffness of rail.	Axle-load in tons (W). According to strength of rail.
20	4	1.5	2.5
25	5	2.2	3.0
30	6	3.0	3.66
35	7	4.1	4.6
40	8	5.4	6.0
45	9	6.9	7.3
50	10	8.4	8.7
55	11	10.1	10.3
60	12	12	12.0
65	13	—	13.5
70	14	—	15.1
75	15	—	17.0
80	16	—	18.6
85	17	—	20.4
90	18	—	22.6
95	19	—	24.7
100	20	—	26.9

Axle-loads were not calculated according to stiffness for rails weighing over 60 lbs. per yard because the stiffness of such rails (B.S. Section) is ample if their strength is sufficient.

5. The axle-loads based on calculations of strength were finally adopted for the 5 ft. 6 in. gauge, and inserted in the schedule of dimensions of 1913 for rails weighing over 60 lbs. per yard. No rails lighter than 70 lbs. per yard are likely to be used on 5 ft. 6 in. gauge railways in India, so no mention of such rails was made in the 5 ft. 6 in. gauge schedule.

6. The axle-loads calculated for rails weighing less than 60 lbs. per yard were much smaller than those permissible under the old uniform scale of 5 lbs. per ton. Experience on the Kohat-Thal and Nowshera-Durgai railways had indicated that the "5 lbs. per ton" rule gives axle-loads which are really too big for light rails but, in view of the low speed at which trains are usually run on light rails, it was decided to retain the old uniform scale for rails not exceeding 60 lbs. per yard. The heaviest rails used on metre gauge and 2 ft. 6 in. gauge railways in India do not weigh much more than 60 lbs. per yard: so the old "5 lbs. per ton" rule was retained in the schedules of 1913 for metre gauge and 2 ft. 6 in. gauge railways.

7. If a metre gauge railway is laid or relaid with new rails heavier than 60 lbs. per yard, the scale of axle-loads prescribed for the 5 ft. 6 in. gauge will no doubt be allowed for the metre gauge as far as the rails are concerned.

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(*b*). *Spacing of Sleepers.*

8. Below the items of the schedules of dimensions which lay down the "minimum weight of rail per yard for each ton of weight on a pair of wheels" there is the following note:—"With closer spacing of sleepers a less weight per yard of rail is permissible."

9. No figures were given to show how much extra axle-load a rail may be permitted to carry by closer sleeper spacing. The omission was deliberate. This subject was carefully considered in 1902-03 when the following algebraical formula was proposed:—

Maximum axle-load=

$$\frac{\text{weight of rail per yard}}{5} \times \frac{30}{\text{sleeper spacing in inches}}.$$

The formula was never promulgated as a Government Rule, but the late Mr. C. W. Hodson suggested that Government Inspectors should bear it in mind when considering special cases.

10. In the present stage of development of rail joint in India it is doubtful if extra sleepers, spaced closer than about 30 inches, justify *any* excess over the axle-loads prescribed in the schedules of 1913.

11. The present general type of joint is a suspended joint with the sleepers on each side of it brought as close together as the fishplates or the practical requirements of packing will allow: it is believed that the joint is usually weaker than the rest of the rail.

12. So long as the rail joint (with sleepers laid as near to it as possible) is weaker than the rest of the rail with the minimum number of sleepers (1,906) per mile, it is obvious that the track cannot be strengthened by inserting additional sleepers, for the strength of the joint would not be increased thereby.

13. In the case of a road in which the joints are *stronger* than the rest of the rail, it is safe to increase the axle-load and to make it vary inversely with the sleeper spacing up to a certain limit which may possibly depend on the resistance of the rails to local crushing.

14. Even when the joints are stronger than the rest of the rail it will probably be found uneconomical to lay any new line with rails so light that they need sleepers spaced much closer than the ordinary 30 inches. It will, however, often be economical to strengthen an existing light track by inserting additional sleepers, instead of renewing the rails, on condition that the rail joint is still as strong as the rail with the reduced sleeper spacing.

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Field Marshal Lord Nicholson, G.C.B., Colonel Commandant, Royal Engineers.

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...d. Bremner, Simla, Lahore, and Calcutta.

MEMOIR.

FIELD MARSHAL LORD NICHOLSON, G.C.B., COLONEL COMMANDANT, R.E.

By the death, in London, on the 13th September, 1918, of Field Marshal Lord Nicholson, G.C.B., Knight of Grace of the Order of St. John of Jerusalem, and at one time A.D.C. General to H.M. King George V., there passed away one of the most remarkable men that ever belonged to the Corps of Royal Engineers. He never commanded even a small unit, in peace or war, yet he rose to be a field marshal; he never graduated at the Staff College, yet he rose to be the Chief of the Imperial General Staff; he had no Parliamentary or family interest or other influence, yet he became a peer of the realm and occupied a position of recognized authority among statesmen; the greater part of his army service was in India, yet when he came to serve at home his influence at once became felt, and he exercised power even in quarters where prejudice against Indian administrators, as such, still lingered. It was all due to sheer brain power and ability. He had in a most remarkable degree the gift of clear perception of the ultimate aim and relative importance of every subject he handled, and the consummate skill with which he expressed his views, and the strength with which he insisted on their adoption, were the means whereby he rose to power and commanded the respect of those associated with him in his life's work.

William Gustavus Nicholson was the son of William N. Nicholson, J.P., D.L., of Roundhay Park, Leeds, and was born on 2nd March, 1845, at the Mansion House, Roundhay. He was educated at Leeds Grammar School under Dr. (afterwards Bishop) Barry, one of the distinguished sons of Sir Charles Barry, the architect of the Houses of Parliament. Among his schoolfellows were Mr. Robert Elliott-Cooper, President of the Institution of Civil Engineers in 1912 and now Chairman of the War Office Committee of the I.C.E. on Hutted Camps, etc., and several others who attained distinction in civil engineering (as well as others who attained high position in other professions). Yet the school was not one which specially devoted attention to engineering, on the contrary a classical curriculum obtained at that time there, as in all schools, to the exclusion of everything else. In Nicholson's case it resulted in his being, to an extraordinary extent, a polished student of classical authors, and an accomplished writer of felicitous expressions and incisive phraseology

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in his own language. The fact, however, of so many pupils becoming leaders in various walks of life and especially in engineering shows how Dr. Barry must have been able to educate them, not only in what Carlyle calls "gerund grinding," but in the far harder task of grasping the broad essentials of life and the practical purposes to which to apply their knowledge.

In 1863 Nicholson passed for the R.M.A. at Woolwich and obtained his first commission in the Royal Engineers in March, 1865. One who served with him as a cadet speaks gratefully of his kindness and consideration to a forlorn "snooker," at a time when discipline at the R.M.A. among cadets themselves was certainly lacking in these qualities. After the usual course at Chatham, and some regimental duty at that station, Nicholson was ordered to the West Indies, and served in Barbados from March, 1868, until 1871. The work he had to do there was probably not very arduous. At all events it seems to have left his vigour and energy quite unimpaired by the climate. Possibly the experience he gained of the essential features of coast fortification, as exemplified in the defence of the islands, was of service to him in taking up the work later of the Defence Committee in India.

After completion of his three years tour in the West Indies he returned to duty again at home but appears to have volunteered for service in India, to which country he was sent in October, 1871. He had married in that year Victorie, daughter of D. Dillon, Esq., a lady who now survives him.

In India, where he was destined to rise to very high position and where for the next thirty years, more or less, his service was spent, he was employed first in the Public Works Department at Hyderabad and subsequently in the Punjab Irrigation Branch. This was then a very favourite employment for R.E. officers, and continued to be so until departmental changes of a drastic nature took place in 1880. At the head of the department were various capable R.E. officers, Gulliver, Crofton, Brownlow, and others, men of the very best stamp of the old East Indian Corps of Engineers, and all imbued with the highest ideals. The work too was on a large scale and well worthy of the best energies of any man. But the life was a severe one and exacting for a young married couple and possibly for this reason, possibly because he found himself departmentally junior to his contemporaries in the Corps, Nicholson left it for Military Works. He was employed at Rawal Pindi and Peshawar on the usual barrack and road work, but at the latter station he carried out the new waterworks scheme, designed by the late Colonel T. C. Manderson, R.E., one of the first of the important waterworks projects which have done so much to improve the sanitary conditions of life in our Indian cantonments. The supply in this case was obtained from the Bara river at the foot of the hills about 10 miles from Peshawar,

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whence after passing through an ingenious arrangement of settling tanks and filters, the water is conveyed by a concrete aqueduct to the cantonments. Concrete in those days was a very different thing from what it is now, for Portland cement was far too costly to be used, and engineers had to make the best use they could of local resources. The work Nicholson did was admirable and has stood the test of years. Moreover, he there learnt something of frontier conditions and of the tribesmen. His regimental promotion was slow. He was thirteen years a subaltern, and during that period had no chance of showing the great qualities that he possessed, but, as in the case of his great contemporary Lord Kitchener, his chance came to him soon after his promotion to captain.

In the autumn of 1878 the Afghan War broke out. Three columns invaded Afghanistan: furthest north, in the Khyber, the central one in the Kurram, and the third through the Bolan Pass. To the last of these Capt. Nicholson was appointed as Field Engineer. The route was an exceptionally difficult one. There was then no bridge at Sukkur over the Indus, the nearest point on the railway was Jacobabad in Sind, then over 100 miles of absolute desert had to be crossed before reaching the sterile and difficult Bolan Pass leading to Quetta. Thence the route traversed the uplands of Peshin, crossed the Khojak Pass, and then, but not until then, reached fairly open country to Kandahar. Nicholson's work was mainly making roads and smoothing away difficulties in the way of water supply for the main columns. He was with the advanced troops that entered Kandahar, and his services were recognized by his being mentioned in despatches. He there came for the first time into contact with another famous R.E. officer, with whom in after years he was much associated, "Buster" Browne (afterwards Major-General Sir James Browne, K.C.S.I., C.B.), who accompanied the Kandahar Column as political officer and specially distinguished himself by the bold capture of Khelat i Ghilzai.

Early in 1879 it was decided to send a column from Kandahar back to India to the Punjab by an unknown route through the Thal Chotiali country due east from Kandahar. The troops composing this column were under the command of General Sir Michael Biddulph, Colonel Browne being the chief political officer and Capt. Nicholson being field engineer. The difficulties of guiding a column of all arms through an unsurveyed barren mountainous country swarming with hostile tribemen were great, but the march was accomplished with success, due to a considerable extent to the energy and ability of the two R.E. officers. Apart from the military value of the exploration, much valuable geographical and other knowledge was obtained. This march came to an end in April, 1879, and Nicholson returned to duty at Simla, believing, as everyone else did, that the Afghan War was ended.

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But the massacre of Sir Louis Cavagnari and his ill-fated companions at Kabul in September, 1879, changed the whole aspect of affairs. Sir Frederick Roberts was ordered to take command of the troops still occupying the Kurram Valley and proceed at once over the Shutargardan Pass to Kabul. He started at once with such officers as were appointed to the Staff of the newly-formed force, among whom were the C.R.E., Colonel Æneas Perkins, and Capt. Nicholson who was to be field engineer of the force. They proceeded with all haste to the front, crossed the Shutargardan, and, at the battle of Charasia, on the 5th October, Sir F. Roberts with his mere handful of troops defeated the strongly-entrenched and superior force of Afghans. This was followed at once by the occupation of Kabul.

One of the first steps to be taken was the establishment of communications at once with India by the Khyber route, as the Shutargardan Pass was sure to be soon blocked with snow. An army was advancing by the Khyber line and the road by this route had already been complete, for all arms, as far as Gandamak, about 70 miles from Kabul, in the earlier part of the war. To complete the remainder, through a wild and difficult country, it was decided that the Khyber column as it advanced should make the road as far as the Lataband Pass about 20 miles from Kabul, and that the remaining portion should be carried out by Sir F. Roberts' small force. This task was entrusted to Nicholson.

The road, some 3 miles from Kabul, crossed the Logar river by a brick bridge of several arches which the enemy had not destroyed, then it traversed a swamp about a mile wide, which was fairly passable in summer but in winter had some four feet of water over the path in parts. For the next 6 or 7 miles the route was easy, passing by the village of Butkhak, noted as being at the mouth of the Khurd Kabul defile of infamous memory in the 1842 campaign. Then followed a series of tangled ravines and stony uplands, culminating in the difficult mountain pass of Lataband.

Nicholson at once perceived that the two crucial points were the Logar swamp and the Lataband Pass. For the former he obtained, somehow, the services, as contractor, of an influential native of Kabul, a man who had been *Kotwal* (head of police) in that city, and who, though probably not immaculate in his dealings with his fellow citizens (or else his looks and reputation belied him), was able to lay his hands on materials and labour and to apply both with skill and energy. Him Nicholson placed under the orders of his subaltern at Butkhak, while he himself proceeded with his other subaltern to Lataband.* The garrison at this isolated mountain pass consisted of one battalion of infantry, two mountain guns, and

* The reasons for adopting the Lataband Pass rather than the Khurd Kabul used in 1841-42 are given in Lord Roberts' *Forty-One Years in India*, vol. ii., pp. 253-54.

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a small detachment of cavalry, under Lieut.-Colonel Hudson, 21st N.I. (afterwards General Sir John Hudson, K.C.B., Commander-in-Chief of the Bombay Army). The force at Butkhak was one company of infantry and a regiment of native cavalry. The R.E. officer there had a fair amount of transport for sending forward such engineering stores as could be obtained locally, to the work at Lataband.

Everything went on well for about a month after work started. Labour came in freely, and supplies of timber, iron, etc., were obtainable. The drainage of the swamp was skilfully and successfully tackled, the materials for the many bridges were being brought to the various sites, the winding tracks up the pass were rapidly assuming shape, when suddenly the storm burst.

The little British army near Kabul suddenly found itself attacked by vast hordes of Afghans, and after some three days' fighting was obliged to retreat under the shelter of the walls of Sherpur cantonments. The little garrison of Butkhak was withdrawn to Sherpur under cover of night, but that at Lataband was too far off and it was left in a position of perilous isolation.

This was Nicholson's opportunity. He had some idea of the possible abandonment, for as soon as the fighting began, he sent orders to his subaltern at Butkhak to load up all his transport animals with food and send them on at once to Lataband, under strong escort. This secured a considerable addition to the supplies of the little garrison. He was indefatigable also in the defence arrangements, and indeed in all matters connected with the safety and well-being of the garrison, and a sufficiently powerful counter-offensive against the enemy.

During the two weeks that the little force was thus "on its own," he was, though nominally only a Sapper captain, really the chief staff officer, and Colonel Hudson was far too honourable a man to take all the credit to himself and to conceal the fact that Nicholson was the main prop on which he leaned in the successful defence which was maintained, until the arrival of the relieving army under Sir Charles Gough on the 22nd December. The relief of Sherpur took place the next day.

This was the first real step in Nicholson's military career. Up to that time he had been an engineer officer pure and simple. From then onwards he became more and more a staff officer, reliable, cool, far-seeing and capable.

The early months of 1880 were passed by him in Kabul, building the permanent defences. But meantime his road to Lataband, which even in December was good enough to take the traffic of the relief force, had now been finished, and was the subject of a special report from Sir F. Roberts, eliciting from the Commander-in-Chief a letter of thanks to Nicholson and his two subalterns.*

* Colonel Hon. M. G. Talbot, C.B., and the writer of this memorial sketch.

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Negotiations for peace and withdrawal were proceeding during the summer months, when suddenly the news of Ayub Khan's victory at Maiwand changed the whole arrangement of affairs, and a force of 10,000 men under Sir F. Roberts was detailed to march to Kandahar.

In that famous march Nicholson was attached to the 2nd Brigade, ultimately taking part, with the 72nd Highlanders, 5th Goorkhas and two frontier regiments, in the battle of Kandahar, where his previous knowledge of the ground was very valuable.

This closed the campaign. Nicholson got the medal and three clasps, bronze star and brevet majority. His reputation as a man of capacity, resource and knowledge was now established. After a period of short leave he returned to Simla as Secretary of the Defence Committee, which had been constituted shortly before to consider all the problems connected both with coast defence, frontier defence and internal arrangements for the safety of India. As Lord Roberts points out in his book, this involved not merely questions of fortification, but of roads and railways, and of the distribution of troops. It was influenced too by considerations of a political nature, *e.g.*, the advance of Russia in Central Asia, and the obligations of the Government of India to the Amir of Afghanistan.

Before Nicholson, however, had progressed very far in his new duties he was again summoned to active service. In the Egyptian campaign of 1882 a contingent under the command of General Sir H. Macpherson was ordered from India. The C.R.E. was "Buster" Browne, and the field engineers Nicholson and Capt. J. Armstrong, with Lieuts. Burn-Murdoch and Mason as assistants. The final orders for this force, however, reduced the numbers, and the orders to Capt. Armstrong and Lieut. Mason were cancelled, with somewhat curious results as we shall see. Browne and Nicholson, though in many important respects unlike, were both men of independence and energy, both full of resource, and gifted with a keen sense of humour. It was a strong combination, and they had in Lieut. Burn-Murdoch a young officer who had already in the Afghan War distinguished himself by great gallantry and ability. They had four companies of native sappers with them.

Reaching Suez on the 20th August, 1882, they set to work to put in a state of defence the principal local buildings and works, as well as construct landing stages, piers, etc., and the railways to the north. Shortly afterwards the whole contingent moved to Ismailia, where they were soon hard at work, repairing roads and canals, and making accessory railway lines. Here they were part of the main force of R.E. that had come from England under General Nugent. On the 10th September the Indian Contingent started for the front and on the 13th took part in the battle of Tel el Kebir and the subsequent advance on Cairo. The Indian Contingent had to make a

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flanking movement on the left of the army, being however fortunate in working along a fair road on the Canal bank, thus gaining both time in the darkness, and ease in progress as compared with the main force which operated on the desert sands. The attack delivered there was a surprise and a complete success. Macpherson at once pushed on to Zagazig. Browne, Nicholson and Burn-Murdoch pressed on with the cavalry (the last-named officer had performed a very gallant action that day already in the attack of a battery for which he was recommended for the V.C.). Nicholson captured four trains under steam, one of which was sent back to help the infantry in their exhausting march. It was a splendid conclusion to the day's success for it cut the enemy's railway system in two, and opened the way next day to the capture of Cairo.

This practically ended Nicholson's share in the war. A ludicrous result, however, followed. In the long list of honours and rewards, there appeared among the list of brevets, the name of Capt. Armstrong, who, as noted above, had been on the original list of R.E. officers ordered to Egypt, but who owing to reduction of establishment, had never been there at all. This inexcusable blunder tickled Nicholson's sense of the ridiculous, and, as he enjoyed nothing more than a practical joke, he applied officially for the brevet, alleging that it was evidently a clerical error, and really meant for him. The application was refused, whereupon Nicholson appealed to the Queen under Sec. 42 of the Army Act. The flutter in official dovecots caused by this audacious act was exactly what he desired. When asked about the success of his appeal, he would reply with much laughter that the highest authorities at the War Office "were very peevish."

Back again to his Defence Committee work at Simla, he was after a while appointed A.A.G., R.E., in India.

Later on, in 1885, Lord Roberts was appointed Commander-in-Chief in India, and took much personal interest in the very important work of the Defence Committee. He has left on record that "it was in a great measure due to Colonel Nicholson's clear-sighted judgment on the many knotty points which came before us, and to his technical knowledge that the schemes for the defence of the frontier, and for the ports of Bombay, Karachi, Calcutta, Rangoon, and Madras were carried out so rapidly, thoroughly and economically, as they were."* This high opinion of Nicholson's ability resulted in his being selected, in 1890, to become Lord Roberts' military secretary, and as "Buster" Browne was then Q.M.G. in India they were again associated in very important work.

Prior to this, however, Nicholson had again work in the field. The operations in Burma which had resulted in the overthrow of the organized forces of King Theebaw, left a legacy of long guerilla

* *Forty-One Years in India*, vol. ii., p. 423.

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warfare of a troublesome nature. Nicholson was employed as A.A.G. on the headquarter staff in 1886–87; he was mentioned in despatches and was given the brevet of lieut.-colonel. It does not appear that he had in this campaign any opportunities of special work, but it was the first in which he was employed on the General Staff (as it would now be called) on which ever afterwards he served in the field.

His work on Lord Roberts' staff is naturally merged in the great work of his illustrious chief, who found in him a most reliable and brilliant adviser. The period was one of many frontier expeditions and of much development. Anyone who knows what the N.W. Frontier was 30 years ago, will recognize that the improvements wrought in the interval are stupendous. At the close of the Afghan War there was not even a metalled road in the whole country between Peshawar and Quetta, with the solitary exception of the Grand Trunk Road between Rawal Pindi and Peshawar. There were no railways beyond Rawal Pindi. The fortified posts all along the frontier were for the most part very antiquated, being those built in the very early years of British occupation.

With a strong combination of experts in the persons of Lord Roberts, Browne and Nicholson, improvements at once came into being. The great frontier road from Dera Ismail Khan to Kohat—a monumental work—was carried out under Colonel Perkins' able superintendence. The railway was pushed on to Peshawar, the Indus bridged at Attock and Sukkur, and the Mari-Attock railway planned. Sir James Browne also strongly advocated a line from Dera Ismail Khan to Quetta through the Gomal; this was surveyed, but rejected on account of the expense. But if it had been carried out, we should have been saved at least two frontier expeditions.

Nicholson's intimate knowledge of frontier conditions was further utilized when, after about two years' duty with the Military Works Branch, as chief engineer (at headquarters), he was made D.A.G. of the Punjab Army in 1895. It will be remembered that, as the General Staff did not come into existence for some 10 years after this date, the A.G.'s branch were then responsible for all training, military policy and operations. Nicholson was therefore Chief Staff Officer to the Lieutenant-General Commanding the Punjab Army Corps, who at that time was Sir William Lockhart, subsequently Commander-in-Chief in India. At the time Nicholson took over the appointment, the Chitral campaign was in full swing, and the strain on the command organization must have been great. Hardly had the effects of this passed away when in 1897 the whole frontier was in a blaze, and the principal part of the campaign was that directed by Sir W. Lockhart himself against the Afridis in Tirah. This was by far the most formidable of any of the frontier tribes, both from their fighting strength, natural qualities and from their central

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position between the Kohat-Kurram country and the Kabul river basin. It was their proud boast that from Tirah "the purdah had never been lifted." But it was to be no longer inviolate.

Sir William Lockhart was by no means the sort of general to be "run by his staff," but he was far too wise a man to try and be chief of the staff as well as general. He had the highest opinion of Nicholson, and like Lord Roberts, trusted his sound judgment and clear grasp of affairs. So in this campaign Nicholson occupied a position of the greatest influence. His knowledge of frontier warfare was now far-reaching and he had studied the problem with the best experts. He was present at the action of the Chagru Kotal, and at the subsequent capture of the Sampagha and Arhanga Passes, with their fierce fighting on most difficult ground. Later on he was at the reconnaissance of the Sarun Sar and the operations at and around Dwatoi in November, 1897. Operations against the Chani Khel Chamkanis, a tribe distinct from, but allied to the Afridis, followed immediately afterwards, and in these he played a prominent part. In December followed operations in the Bara valley and in the Bazar valley, in the mountainous country south of the Khyber, until at the end of the year the whole Afridi country had been swept from end to end. For this campaign he was awarded the frontier medal with two clasps and made a K.C.B.

He returned for a short time to his duties at the headquarters of the Punjab Command, but later in 1898 was promoted to be Adjutant General in India, at that time the highest appointment on the staff.

The experience of an important campaign always results in much revision of methods and organization, and a busy task was before him. He had, however, barely settled down to its accomplishment when the initial disasters in South Africa called him again to active service. Lord Roberts was summoned to take command of our armies in the field, and he sent for Kitchener from the Sudan and Nicholson from India, to assist him in his great task. To both of these distinguished officers of our Corps, but to the latter especially, was committed the duty of organizing the transport. The entire system had to be recast. Transport had been, up to the time of Lord Roberts' arrival, based on a regimental system, which had certain advantages, but it was extravagant and wanting in mobility for general purposes. The whole demanded reorganization. The regimental transport was formed into transport companies, and concentrated for redistribution in proportion to the wants of the service as a whole, and in accordance with the needs of actual operations. Nicholson had been summoned from India to be Military Secretary, and he was one of the very few officers to whom Lord Roberts' plan of campaign was made known, and he was subsequently largely employed by his chief in his personal capacity for a variety of responsible and confidential duties, but it was as Director

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of Transport that he exercised, at first, the most important influence on the progress of the campaign. He was present at Paardeberg, and, in the advance later, at the actions at Poplar Grove, Drei Fontein, Vet and Zand Rivers, in the operations near Johannesberg, Pretoria and Diamond Hill, and in the operations in the Transvaal, east of Pretoria during the latter half of 1900. During part of this time he was employed on Intelligence Work, in addition to other duties. In October, 1900, he returned to India. For his services in the S. African War he was promoted Major-General.

In the spring of 1901 he was appointed Director-General of Mobilization and Military Intelligence at Headquarters, and for the first time since he was a junior subaltern he served in England. The position he now held was one of the greatest importance, and it was one in which his great experience of war and wide grasp of affairs was specially valuable. He succeeded another very gifted R.E. officer, the late Major-General Sir John Ardagh, K.C.M.G., K.C.I.E., C.B., who had been Private Secretary to Lord Lansdowne when that nobleman was Viceroy of India at the same time that Lord Roberts, as Commander-in-Chief, had Nicholson as his military secretary. Ardagh had worked up the Intelligence Branch to a high pitch of efficiency, and Nicholson now took up the work in such a way as to make it the nucleus of that General Staff Bureau of Information which it now has become. In those days the Intelligence Department was a branch of the Q.M.G.'s office, and supplied information as and when required. But Nicholson held that it should be a controlling and governing power, that on its reports and information the policy of our army, its training, its whole being, should be based. This was not the War Office tradition, which at that time held that policy and training should be governed by the Adjutant-General. Nicholson was not imbued with any War Office traditions. He held that the military policy of the country must be settled in its broad outlines by the Cabinet, under the authority of the Sovereign, and that it was the business of the Director of Intelligence so to furnish the Cabinet with such information of what was going on in the world, as would enable them to decide what their policy should be, and then when that policy was determined, it was the business of the Army Staff to work out all details of training, organization, etc., in such a way as to give effect to the policy within the necessary limitations of expense, recruiting and other concomitants of our national life. To carry his views in the teeth of much opposition was Nicholson's task, and although he laid the foundation of his great plans then, it was not until he became Chief of the General Staff at a later stage that he was able to carry them out in their entirety. Even then, however, he was making his mark as a powerful administrator.

Meantime he was again called to the East on active service,

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early in 1904, as Chief Military Attaché to the Japanese Army in Manchuria, where he remained for a little more than a year. To a man of his wide experience and keen intellect it was an experience of the greatest value, for the operations which he witnessed were of war on a far larger scale than anything he had witnessed before, and the army to which he was attached was not only imbued with the highest courage and patriotism but it had been eagerly assimilating from all European sources every possible lesson that was of value. Nicholson was granted the Japanese war medal and the Grand Cordon of the Rising Sun.

In 1905 on return from the Far East, he was offered a command in the Mediterranean, but this he declined, preferring to go on half-pay until something more in accordance with his experience and capacity presented itself. He had not long to wait, for at the end of that year, when Sir Herbert Plumer vacated the appointment of Q.M.G. at Headquarters, Nicholson was appointed to succeed him. He was now a member of the Army Council, and in a position to exercise direct influence on the policy of administration. In this appointment he continued for some two years.

From this appointment, in 1908, he was promoted to be Chief of the General Staff, succeeding Sir Neville Lyttelton. This was subsequently made "Chief of the *Imperial* General Staff," as it embraced all the staff operations of the Colonial and Indian armies as well as those of the Mother Country.

It need hardly be said that in such a position the talents of a great student of war and of public affairs have a wonderful opportunity. The General Staff of the Army was in 1908 a more or less amorphous body, composed of many brilliant and capable men it is true, all of whom, with very few exceptions, had been through an admirable course of training at the Staff College, and a still more searching test of capacity in actual war. But they lacked the power and influence that united action gives, and this Nicholson largely supplied. He had a great knowledge of character, and power of selecting good men, and he wielded that power with vigour and impartiality. Men might fear him, or dislike him, but all were imbued with the respect that is commanded by capacity, decision and impartiality. During those years of welding together the various personal elements of the General Staff, he was collating information from abroad, organizing units into divisions and other commands, supervising training, and all the time keeping in close touch with the civil power so as to subordinate the military weapon to its recognized policy. For it will be remembered that those years were ones of anxious endeavour on the part of our Government to maintain peace in Europe, and the shadow of the Great War was beginning to overcast the political sky. Whether Nicholson gave the wisest advice to the Cabinet on the subject, or whether the

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Cabinet was to blame for not accepting his suggestions, no one can now say who is not in the secrets of the late Government. But this at least may be said that when a definite policy was fixed, that a certain Expeditionary Force should be maintained for overseas, and a Territorial Force should be organized for home service, it became the duty of the Chief of the Staff to see that each and every component part was ready for such eventualities as might arise. How far this was done can best be answered by the achievements of the Old Army in 1914–15, in the speed, secrecy and celerity with which it crossed to France in the early days of the war, in the splendid victories of the autumn and the bitter winter of that year, and in the readiness and devotion of the Territorial Force in the early days of 1915 and ever since. The "Old Army" was, as we all know, far too few in numbers, and Nicholson's old chief, Lord Roberts, had pleaded in vain for a fuller recognition of our national danger, and for a more adequate provision against it, but, within the limits that the politicians had laid down, there was no question of inefficiency. The General Staff, under Nicholson's supervision, had made the weapon at their disposal as keen and polished as human skill could make it.

Nicholson transferred his great responsibilities as Chief of the Staff in the spring of 1912 to Sir John French. He had been promoted to the rank of Field Marshal in the previous year and had been made A.D.C. General to the King, when His Majesty came to the throne in 1910. On retirement from the Army Council in 1912 Sir William Nicholson was raised to the peerage as Baron Nicholson of Roundhay, Yorks.

This was the culminating point of his career, but he still had opportunities of useful service. In 1912 he was appointed head of a Commission, consisting of Sir William Meyer (of Mesopotamian notoriety later), Sir Percy Lake and Sir Robert Scallon, to enquire into the expenditure of the Indian Army. Nicholson therefore returned to India, for a final visit, in the summer of 1912, remaining there for about a year. The recommendations of that Committee, whatever they may have been, were overshadowed by the Great War, and were not carried into effect.

He continued to be a member of the Committee of Imperial Defence and during the war he was a member of the Committees which investigated the conduct of operations in Gallipoli and Mesopotamia. He was also chairman of the Territorial Force Association for London. In 1916 he was appointed Colonel Commandant, R.E.

Lord Nicholson was essentially a man who did not bid for popular applause. He was a brilliant speaker ; on the few occasions when he was obliged to make a speech he could do so with the most amusing wit and charming humour, but he rarely spoke in public. He wrote with admirable point and perspicacity, but his name never appeared

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in any periodical or public letter. As a member of a mess, in the old days, he was an intensely amusing comrade, full of humour and unexpected jokes, but he was apparently quite indifferent to the opinion of his brother officers. He was not interested in the internal matters of the Corps, seldom came to the Corps dinner or to any of the Corps meetings, and admitted few of his brother officers to intimate friendship. Yet to the few that did know him well, he was full of sympathy and kindness, and one cannot help feeling that if in his early years he had been in touch with the admirable comradeship which exists between officers and men in the R.E. units (with whom he never served) it would have elicited more of that sympathy and would have added to his own happiness. As an executive engineer he was admirable in his dealings with his assistants, giving them clear and precise instructions, and then leaving them a free hand in carrying these out, without petty interference or worrying over details. And the distinguished officers under whom he served, Sir James Browne, Lord Roberts and Sir William Lockhart, not only admired his talents but had the warmest appreciation of his personal characteristics. The good opinion of such men was doubtless what he prized, and as regards others he was indifferent.

G. K. SCOTT-MONCRIEFF.

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NOTICE OF MAGAZINE.

REVUE MILITAIRE SUISSE.

No. 10.—*October*, 1918.

MILITARY TRAINING AND MORALE OF THE SWISS SOLDIER.

The author of the original article quotes an extract from the order issued by General Wille to the Swiss Army in August, 1914; therein the General stated:—"Neither improved armaments, nor numerical superiority, nor the dispositions of troops made by the Higher Command can, as a primary cause, ensure success in war. Success, depends above all things, upon *the spirit that animates an army*. This spirit springs from the strong desire of each and every one to bear with pleasure his share of the burden for the security and independence of the Fatherland."

It is, of course, universally admitted that the *morale* of an army is the true measure of its value. This historical truth, says the author of the original article, cannot be repeated too often. The great Corsican has declared that in war the *morale* is to the physical of an army in the proportion of three to one. Again, in our own day, Marshal Foch has expressed himself in terms which show that the moral qualities of a soldier still count for far more than do all his other qualities.

The author of the original article having shown that there are not two opinions on this important matter boldly asks the question: Are we (*i.e.*, the Swiss) ready?

He enquires, indeed, whether in the event of the Swiss Army being compelled to take the field on the morrow, it would be found ready for the task in hand, from the material point of view as well as that of *morale*. He does not further pursue the question relating to the material and technical aspects of the preparations made in Switzerland to cope with a war, but with regard to the question whether the Swiss Army is ready as regards its *morale*, he thinks that hardened optimists might reply: Perhaps! His own opinion, however, is that the person in Switzerland, whether he be civilian or soldier, who can honestly say, in view of all the outward signs of discontent, distrust, disgust with military service, etc., existing in the country, that the *morale* of the Swiss Army is satisfactory, must be both deaf and blind. It is no use crying over spilt milk, in effect, continues the author of the original article; the best thing to do, he suggests, is to combat the unfortunate state of affairs known to exist and to adopt energetic preventive measures lest worse calamities befall the Republic.

It is stated that numerous articles have appeared in the Press and many pamphlets have been published, which bear on the unsatisfactory state of the *morale* of the Swiss Army; and in this connection, a reference is made to Dr. Bürke's *Volk und Armée* (Fehr, St. Gallen) and to Captain

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Vallière's Article published in the *Revue* for January, 1918 (*vide R.E. Journal* for March, 1918).

The causes responsible for the state of affairs complained of are said to be as follows:—The monotonous and irksome character of Army routine; *false* drill; disregard of regulations and conduct contrary to discipline on the part of officers; abuses of authority by certain C.O.s., etc. Although the grievances enumerated in the original article are numerous, the statement is made that they could be added to.

It is pointed out that the Swiss soldier, when comparing his lot with that of his civilian friends, finds that he is being penalized in many ways by giving up a part of his time to the service of the State; whilst his family experience difficulty in making both ends meet, the civilian is able to earn good wages and can, in other ways also, get the better of the man in uniform. The author of the original article admits that the problem under discussion is one the solution whereof is most difficult; the increase already granted in the soldier's pay has not been sufficient, he thinks, to adjust the inequalities complained of. Attention is called to this matter, he continues, in order that those who are in a position to deal with the difficulty and provide remedies may take the question in hand and do what is equitable.

The question of improving the *morale* of the Swiss Army is, it is admitted, primarily a matter for the officers to deal with; a great deal can be done, it is pointed out, by military training conducted on proper lines.

An examination is made, in the original article, of the course of military training through which Swiss soldiers are put, and the opinion is expressed that too much attention is given to mechanical details in the instruction of the soldier, whilst essential matters of importance are largely lost sight of during the training period. The instructors in the Swiss Army, it is hinted, do not employ the most suitable methods in the training of their men; this seems to be due in part to the faulty instruction which they themselves have received. (*To be continued*).

The Re-organization of the Swiss Aviation Service.

It is stated in the original article that for some months past the Swiss Press has been directing attention to the Swiss Air Force. The hope is expressed that these persistent attacks may result in the introduction of the necessary reforms in the Fifth Arm. Regret is expressed that no spontaneous effort has been made within the Service to effect the improvements so badly needed.

The author of the original article states that in Switzerland, as has been the case in other countries, many faults have been committed in relation to military aviation. However, other countries have shown that past errors in this field, as in others, can be amended, and it is suggested that the time has arrived for Switzerland to follow the example of others.

The principal mistake made in Switzerland has been that the Air Force has never had a supreme chief. All those who have wished to and could have organized an Air Force have come up against and been held up by Commissions with ill-defined powers and offices possessing no

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authority. The situation has not been improved by the fact that aviation has been directly under the General Staff, and, in consequence, without any one in particular to take up the cudgels on its behalf.

Four years ago, those in high places in the Swiss Army were, it is stated, still sceptical as to the military value of aviation. The fear of seeing the Army Estimates increased seems to have clouded the reasoning powers of those in authority. M. Hoffmann, who was responsible for the Military Department, held the purse strings very tightly when it was a question of providing the needful for the Air Force. It was in consequence of his attitude that private initiative came to the rescue of military aviation in Switzerland.

Thanks to the efforts of the Committee over which Colonel Audeoud presided with conspicuous zeal and ability, the public subscriptions to the Aviation Fund amounted at the end of 1913 to $1\frac{3}{4}$ million francs. The donors intended this sum to be spent in the purchase of aeroplanes. The Aviation Commission had, in 1914, placed orders for six biplanes with the *Luft-Verkehrs Gesellschaft* of Johannisthal (near Berlin); deliveries thereof were due when the war broke out.

On the outbreak of hostilities the Swiss Government immediately commandeered all the aeroplanes at the Exhibition at Berne and those belonging to private aviators; 7 machines were thus obtained.

Captain T. Real, of the Swiss Cavalry, was placed in command of the Aviation detachment; he was one of the pioneers amongst Swiss pilots. About a dozen aviators volunteered for service in the Air Force and were accepted. Apparently only three of them alone remain in the Service to-day. The author of the original article states that he would prefer those who have left the service personally to give the reasons why they severed their connection with the Force.

In 1915, it was announced that the Air Force had been placed under the Aviation Commission. The headquarters of the force were established at Dübendorf at the beginning of the year mentioned and three months later it issued pilots certificates to the first four of the flying men trained there. About the same time, deliveries of the first batch of aeroplanes manufactured in Switzerland were made to the Aviation Commission; these machines were biplanes of the *Aviatik* type. At this time the question of the proper position for the propeller of military machines was being hotly debated in Switzerland; the Aviation Commission decided to adopt the propulsive position for the propeller in the machines ordered to be built at the military workshops.

In the opinion of many Dübendorf was considered an unsuitable place, from the point of view of defence, for aerodromes. In April, 1915, the cantonal authorities and private persons were appealed to to assist in the provision of landing grounds. Only in Lausanne was there a response to this appeal. A Federal Decree was signed on the 13th August, 1915, to deal with the Air Force, whose numbers had by that date increased sufficiently to justify such a step being taken. Shortly afterwards difficulties arose in connection with the Air Force; the situation at the time that the original article was written was still unsatisfactory. Colonel Audeoud had already resigned his position some time previously for reasons which are not stated, but can be guessed.

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The state of affairs finally became such as to necessitate the appointment of a Commission to enquire into matters connected with the Aviation Service; the Commission was still sitting when the original article was sent to press.

It is thought in some quarters that the existing difficulty in connection with the Swiss Air Force may be met by the appointment of an officer to take charge of all the executive work in connection with the Aviation Service. In this event the present Chief will have to confine his attention to administrative details. The author of the original article points out that timid half measures will not cure the defects complained of.

A great part of the present trouble has arisen owing to acute differences of opinion on the question of the design of machines; and the machine is thus being made the scape-goat for all the defects in the Aviation Service.

It is pointed out that since the beginning of the war, the French have standardized their machines, so also have the British, and the Germans are on the point of doing so.

The French have, it is stated, six categories of machines, each containing several types or models. These categories are:—

1. The single-seater chasing machine—extra high speed.
2. The two-seater chasing machine—extra high speed.
3. The three-seater (double-motor) machine for photographic reconnaissance work.
4. The two or three-seater contact machine.
5. The two-seater day bombing machine.
6. The two or three-seater night bombing machine.

The author of the original article expresses the opinion that the Swiss Air Force requires machines of three categories only at the present time, viz.:—

1. A two-seater machine which can be used for all purposes.
2. A single or two-seater chasing machine possessing extra high speed.
3. Instructional machines with duplicate controls.

In many quarters of Switzerland, it is being urged that the construction of aeroplanes should no longer be carried out in Government workshops, and that the whole of this work should be transferred to private firms. The author of the original article is of opinion that the time for so drastic a change has not yet arrived in Switzerland; the situation in that country is not comparable with the conditions prevailing in Great Britain and in France, so that the practice in these countries would not necessarily give similar results if adopted in Switzerland.

The statement is made that what the Swiss Air Force most wants is a strong disciplinarian to command it and to keep in check the *individualisme à outrance* prevailing in the youngest arm of the Helvetic Army.

Divisional Training Centres.

The article which appeared in the number of the *Revue* for August, 1918, on the "Training Centre of the Swiss 1st Division" (*vide R.E. Journal* for October, 1918) appears to have attracted a considerable amount of attention in Switzerland. The observations of Major F. Badoux on Divisional Training Centres were published in the number of the *Revue* for September, 1918 (*vide R.E. Journal* for November, 1918);

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a further contribution on the same subject, from the pen of Captain Decollogny, is published in the number of the *Revue* now under notice.

Capt. Decollogny is of opinion that the anonymous author of the first article of the series was too severe in his criticisms of the infantry of the Swiss 1st Division; he himself is satisfied that during the period of its mobilization the Swiss infantry has improved immensely in military efficiency. The controversy now in progress is of domestic rather than general interest. The Swiss Army has special difficulties of its own to contend with in connection with training matters, and close acquaintanceship with the conditions prevailing in Switzerland is necessary for a proper understanding of the points at issue in the correspondence to which reference is made here.

Captain Decollogny points out that specialization is a necessary feature in the preparation of a modern army in war; he is in favour of decentralization and recommends that battalion training centres shall be created in addition to divisional training centres. Frequent inspections of the battalion training centres by the instructors of the divisional training centres is also recommended by him, as a means for providing that the instruction given thereat shall be on uniform lines throughout the formation.

MEDICAL SERVICES OF THE FRENCH ARMY DURING THE RECENT OPERATIONS.

The author of the original article states that, a "war of movement" having taken the place of trench-warfare on the Western Front, a reorganization of the Medical Services of the French Army became necessary; in consequence, radical alterations have been made therein.

Trench-warfare permitted the surgical treatment of the wounded to be carried out under perfect conditions; the formula "early operations, rapid evacuations" sums up in a few words the methods which were in vogue.

One of the results of the "war of movement" has been that the splendid Evacuation Hospitals, a great number of which had been established at distances of from 6 to 9 miles behind the front line of the trench system, can no longer be utilized for the purpose for which they were designed.

When the "war of movement" began in April last, a new programme was drawn up for the treatment of the wounded; it came into operation at the beginning of June last.

Under the new scheme only men who had been so dangerously wounded that it would have been unsafe to subject them to a long journey were operated upon at the advanced or primary Evacuation Hospitals. Every other wounded man was sent back to a secondary Evacuation Hospital—situated from 30 to 120 miles behind the front. A system of inspection was established so that in the event of the condition of a patient having taken a turn for the worse whilst on the journey between the primary and secondary Evacuation Centres an operation could, if necessary, be at once performed. Trains were halted at medical Regulating Centres to enable this inspection to be carried out and in order to detrain those whose condition was such as to render an immediate operation necessary.

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The lightly wounded, those who had been gassed and the sick were sent back by stages to hospital zones in rear of the fighting line or in the interior of France.

This scheme involved the creation of immense surgical centres, containing 2,000, 3,000 and even 4,000 beds apiece.

The beds were, in such cases, housed in temporary structures, erected in open country, and in proximity to suitable railway communications. A conspicuous feature of the organization was the special transport service consisting of vehicles of various kinds for the conveyance of men and materials. Multiple hospital trains were also prepared, so as to carry back the wounded in as short a time as possible from the primary to the secondary or rearward Evacuation Centres. On an average these trains were arranged to carry 300 cases apiece. The rivers and canals were also utilized as far as possible for the evacuation of the wounded. It is estimated that under this scheme, on an average, operations were carried out within 20 to 30 hours after the wounds had been received. As a rule the conditions of wounds is such that even after an elapse of 48 or even 50 hours operations can be carried out in safety and with every prospect of success.

Notes and News.

Switzerland.—Satisfaction is expressed at the fact that the end of the war was in sight. It is suggested that when peace reigns once more the political and military authorities will have leisure to look into that which is amiss in the Swiss Army and to put things right.

It is pointed out that the advantages of "unity of command" have been abundantly proved in the great war. The Central Powers provided for it almost from the opening days of the campaign; the Western Powers were converted to the idea at the eleventh hour. The twelfth hour is striking; yet Switzerland, with its small Army of six divisions, it is said, is still without "unity of command"!

An extract from a letter sent to the newspapers by a staff officer, on the 22nd August last, is published in the *Revue*; therein the writer attributes the troubles existing in the Swiss Aviation Services and in other branches of the army to the "mischievous dualism" created by the Swiss laws in matters connected with the command of the Army and the Territorial Force.

The writer of the original communication to the *Revue* considers that the time has arrived to mend or end the defects in the Swiss military laws and in the vices of the Swiss Administrative system. He says that it is widely known as a fact that the Swiss Army is under the direction of an association of officials who are at loggerheads with one another. Further, he blames the Helvetic Parliament for its interference in Army affairs.

Matters in connection with the Swiss Air Force are touched upon; it is recognized that the members of this Force, as of the Army, as a whole, are sound at heart, all that is wanted is that the valuable material of which it consists shall be properly exploited.

The discovery that the German military attaché had a finger in the explosives affair at Zurich, and the incident connected with the killing of a Swiss airman, by a German airman, whilst the former was flying

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over Swiss territory, have naturally caused indignation and excitement in Switzerland. It is suggested that the time has arrived for the Swiss to take a firm line in connection with the ever-recurring scandals of these kinds.

Portugal.—A special correspondent furnishes a detailed account of the happenings of the 9th April last, when the Sector on the Western Front held by the Portuguese was rushed by the Germans; it is based on the Portuguese official despatches. The Portuguese troops suffered particularly heavy casualties on this occasion.

International News.—A brief account is given of the second Battle of the Marne (15—25th July, 1918) under this heading.

INFORMATION.

Switzerland.—A contribution by Lieut.-Colonel Arthur Foujallaz is published under the title "Fausse route." There is considerable difficulty in estimating the true value of the military organization of a country, writes Colonel Foujallaz, when for many decades one method, and one alone, has been held worthy of imitation as has been the case in Switzerland. He makes a satirical reference to the exaggerated attention which has been paid in the Swiss Army to the practising of the German "ceremonial step," the *paradeschritt;* the noise made by troops in "marching past" have, in the opinion of some, he thinks, been taken as an outward and visible sign of their true fighting value.

Matters connected with the training of the Swiss Army have been, it is asserted, in a state of hopeless muddle since the Great War began. Part of this muddle is attributed to the fact that the difference in the conditions of training existing in peace time as compared with those of war time have not been properly appreciated. The desire for reform caused the authorities to attempt changes in so many directions that everything was turned topsy turvy; this was even the case with institutions which had been brought into existence after careful consideration by competent minds.

Complaint is made that a great variety of methods have been introduced in the carrying out of the instructions contained in the Swiss Training Manuals, etc., *e.g.*, in the matter of saluting, of the manual exercise, of the firing exercise, of gymnastic training, etc. Even in the matter of the uniform little regard is paid by officers to the orders on the subject; instead of wearing garments cut according to sealed patterns, many officers provide themselves with uniforms fashioned on *chic* models of Paris or of Berlin.

Colonel Foujallaz points out that the theory of "*laisser-faire*" and of the "*pourvu pas d'histoire*" is out of place in a military organization, and he feels strongly that the time has arrived for wheeling the Swiss Army into line and for exacting a strict obedience to the Regulations. He considers that it would be an act of cowardice on his part, and prejudicial to discipline, if he did not publicly declare that the Swiss Army was on a "wrong road."

Bibliography.—A notice of the following work by a Swiss eye-witness is published *Somme und Oise: Die verwüsteten Gegend.* Orell Fussli, Zurich, 1918.

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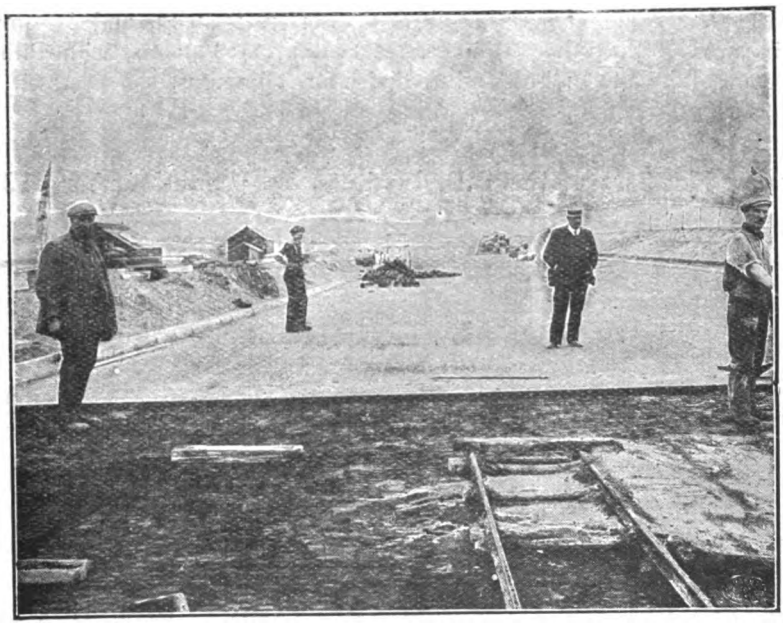

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